IVC Series Small PLC

Programming Manual

Version V1.0
Revision date Nov 26, 2011

Invt Auto-Control Technology provides customers with technical support. Users may contact the nearest Invt local sales office or service center.

Copyright © 2011 by Invt Auto-Control Technology Co., Ltd.
All rights reserved. The contents in this document are subject to change without notice.

Invt Auto-Control Technology Co., Ltd.
Address: 4# INVT Building, Gaofa Industrial Park, Longjing, Nanshan District, Shenzhen, China, 518055
Homepage: www.Invt.com.cn
E-mail: ethan@Invt.com.cn

Prologue

Target reader

This book is suitable for the automation personnel who need to master the PLC programming, system design and commissioning. This book can also serve as a reference for anyone who are interested in futhering their PLC programming knowledge.

Content of this book

This book details the principles, hardware resources, programming languages and instructions of the IVC series small PLC. A variety of application illustrations are used to help you understand the rich functions of the PLC.

Features of this book

The chapters in this book develops from general to details, each having its independent topic. You can either read thoroughly to gain overall knowledge of the IVC series small PLC, or consult in some of the chapters for technical reference.

Reading instructions

1. For readers unfamiliar with PLC

   It is recommended to start with chapters 1~4 to learn the basic PLC knowledge, including PLC function description, programming languages, elements & data, addressing modes, program annotating function, main program and subprograms. Afterwards, you can read other chapters to cater for your needs.

2. For readers familiar with PLC

   You can jump directly to *Chapter 5 Basic Instructions* and *Chapter 6 Application* Instructions, which provide complete and detailed explanation for the instructions of Invt IVC series PLC. In addition, the *Appendix 9 Instruction Index* and *Appendix 10 Classified Instruction Index* provide tools for locating the instructions in the orders of alphabet and classification respectively.

Related documents

You can refer to the following books while reading this book:

- *IVC1 Series PLC User Manual*
- *IVC2 Series PLC User Manual*
- *AutoStation Programming Software User Manual*

Contents

Chapter 1 Product Overview....1
Chapter 2 PLC Function Description....8
Chapter 3 Element And Data....31
Chapter 4 Programming Concepts....44
Chapter 5 Basic Instructions....54
Chapter 6 Application Instructions....70
Chapter 7 SFC Tutor....205
Chapter 8 Using High Speed I/O....226
Chapter 9 Using Interrupts....235
Chapter 10 Using Communication Function....244
Appendix 1 Special Auxiliary Relay....263
Appendix 2 Special Data Register....270
Appendix 3 Reserved Elements....276
Appendix 4 Modbus Communication Error Code....277
Appendix 5 Inverter Instruction Error Code....278
Appendix 6 System Error Code....279
Appendix 7 Modbus Communication Protocol (IVC Series)....281
Appendix 8 ASCII Code Table....290
Appendix 9 Instruction Index....291
Appendix 10 Classified Instruction Index....296

Chapter 1 Product Overview

This chapter presents the product makeup, plaftform of the programming software and network configuration of the IVC series small PLC.

1.1 Product Introduction 2
1.1.1 Product Specification 2
1.1.2 Outline Of IVC1 Series Basic Module 4
1.1.3 Outline of IVC2 Series Basic Module 4
1.2 AutoStation Programming Software 4
1.2.1 Basic Configuration 4
1.2.2 AutoStation Installation 5
1.2.3 AutoStation Operation Interface 5
1.2.4 Programming Cable 5
1.3 Communication Function 6
1.3.1 Modbus Protocol Network 6
1.3.2 N:N bus Protocol Network 6
1.3.3 Free Port Protocol Network 6
1.4 Makeup Of Document System Of IVC Series Small PLCs 7
1.4.1 Model Selection Instruction 7
1.4.2 Basic Module User Manual 7
1.4.3 Programming Manual 7
1.4.4 Programming Software User Manual 7
1.4.5 I/O Extension Module User Manual 7
1.4.6 Special Module User Manual 7

1.1 Product Introduction

The IVC series small PLC, comprising the IVC1 mini-scale series and IVC2 small series, is a high performance product suitable for modern industrial control.

The IVC series PLC products have integrated structure, built-in high performance microprocessor, operation control system, integrated I/O and extension bus. The series also include I/O modules and special modules. The basic module has 2 integrated communication ports, and the sytem can connect to the profibus network through a profibus extension module. The basic module I/O is capable of high-speed counting and high-speed output that can be used for exact locating. The powerful AutoStation programming software provides 3 standard programming languages and commissioning & monitoring functions, and boasts complete user program protection mechanism.

1.1.1 Product Specification

Table 1-1 PLC basic module

			IVC2	IVC1
I/O	Digital I/O points		10-input /6-output 14-input /10-output 20-input /12-output 24-input /16-output 32-input /32-output 40-input /40-output	10-input /6-output 14-input /10-output 16-input /14-output 24-input /16-output 36-input /24-output
	Total number of supported I/O points		512	128
	Max. number of special modules		8	4
	High speed pulse output		2×100kHz (for transistor output only)	
	Single phase counting channel		6: 2(50kHz) + 4 (10kHz)	
	AB phase counting channel		2: 1 (30kHz) + 1 (5kHz)	
	Max. total frequency of high-speed counter		80kHz	60kHz
	Digital filtering		X0 ~ X17 (Input filtering constant: 0 ~ 60ms)	X0 ~ X7 (Input filtering constant: 0, 8, 16, 32, 64ms)
	Max. relay output current	Resistive load	2A/1 piont 8A/4-point-group common terminal 8A/8 point-group common terminal	
		Inductive load	220Vac, 80VA	
		Illumination	220Vac, 100W	
	Max. transistor output current	Resistive load	Y0, Y1: 0.3A/1 point Others: 0.3A/1 point, 0.8A/4 points, 1.6A/8 points. For each point above 8-point, the total current raises 0.1A.	
		Inductive load	Y0, Y1: 7.2W/24Vdc. Others: 12W/24Vdc	
		Illumination	Y0, Y1: 0.9W/24Vdc. Others: 1.5W/24Vdc	
Registor	User program		12k steps (24kByte)	
	Memory hold upon power failure		Yes	
	Max. number of memory hold elements		User set (up to 200 C elements)	320 bit elements, or 180 word elements
	Hardware support and sustainable period		Backup battery. Life span: 1 year.	EEPROM. Permanent

		IVC2	IVC1
Elements	Timer	100ms precision: T0 ~ T209 10ms precision: T210 ~ T251 1ms precision: T252 ~ T255	
	Counter	16-bit up counter: C0 ~ C199 32-bit bi-directional counter: C200 ~ C235 32-bit high speed counter: C236 ~ C255	
	Data register	D0 ~ D7999	
	Local data register	V0 ~ V63	
	Offset addressing register	Z0 ~ Z15	
	Special data register	SD0 ~ SD255	
	Auxiliary relay	M0 ~ M1999	M0 ~ M2047
	Local auxiliary relay	LM0 ~ LM63	
	Special auxiliary relay	SM0 ~ SM255	
	State relay	S0 ~ S991	S0 ~ S1023
Interrupt	Internal timed interrupt	3	3
	External interrupt	8	16
	High-speed counter interrupt	6	6
	Serial port interrupt		8
	PTO output complete interrupt		2
	Power failure interrupt		1
General	Basic instruction processing time	0.09μS	0.3μS
	Real time clock	Yes (power-failure memory-hold time: >1 year)	Yes (power-failure memory-hold time: 100 hs)
	Analog potentiometer	2 (precision: 8-bit)	2 (precision: 8-bit)
Communication	Ports	PORT0: RS-232 PORT1: RS-232/RS-485	
	Protocol	Modbus, Free port, Programming port	Modbus, Free port, N:N bus, Programming port
Access control and user program protection	Password type	Upload, download, monitoring	Upload, download, monitoring, subprogram, formatting enabling
	Upload disabling	Yes	Yes
MTBF	Relay output	200,000 hs (ground-fixed, minimum mechanical stress and temp./humidity control)	
		100,000 hs (ground-fixed, minimum mechanical stress & no temp./humidity control)	
	Transistor output	300,000 hs (ground-fixed, minimum mechanical stress and temp./humidity control)	
		150,000 hs (minimum mechanical stress and no temp./humidity control)	
Life span of output relay contacts	220Vac/15VA/inductive	1s ON / 1s OFF, 3,200,000 times	
	220Vac/30VA/ inductive	1s ON / 1s OFF, 1,200,000 times	
	220Vac/72VA/ inductive	1s ON / 1s OFF, 300,000 times	
Power supply	Input voltage range	90Vac ~ 264Vac (for normal operation)	85Vac ~ 264Vac (for normal operation)
Note: See *IVC1 Series PLC User Manual* for the speicifcation, installation instruction, operation and maintenance of IVC1 series PLCs. See *IVC2 Series PLC User Manual* for the speicifcation, installation instruction, operation and maintenance of IVC2 series PLCs.			

1.1.2 Outline Of IVC1 Series Basic Module

The outline and structure of the IVC1 series basic module are shown in the following figure (example: IVC1-1614MAR):

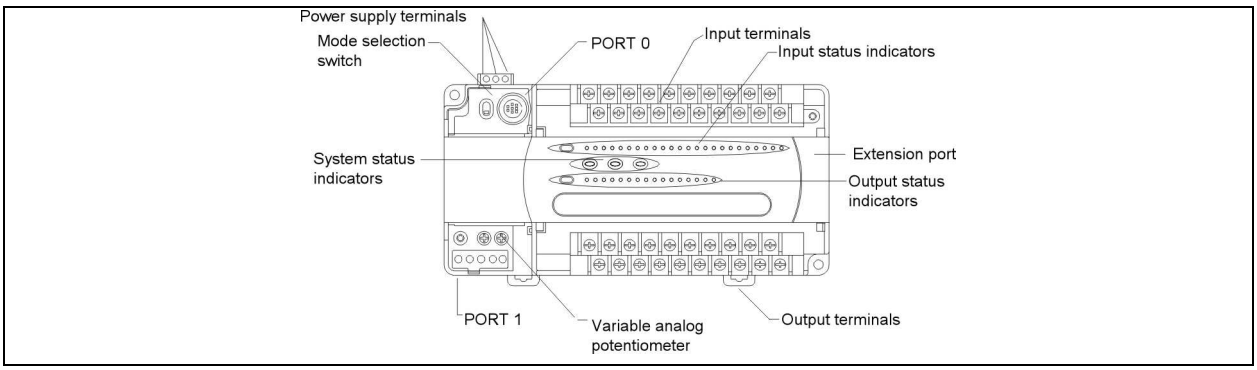


Figure 1-1 Outline and structure of IVC1 series basic module

As shown in Figure 2-1, PORT0 and PORT1 are for communication. PORT0 is RS232, and use socket Mini DIN8, while PORT1 is RS485 or RS232. The bus socket is for connecting extension modules. The mode selector switch can be set to ON, TM or OFF.

1.1.3 Outline of IVC2 Series Basic Module

The outline and structure of IVC2 series basic module is shown in the following figure (example: 64-point basic module):

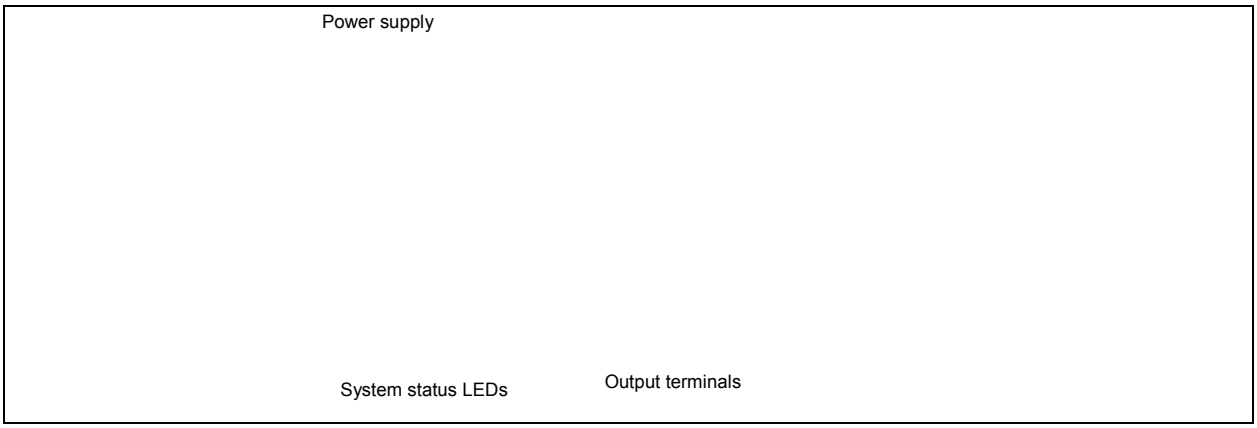


Figure 1-2 Outline and structure of IVC2 series basic module

The battery socket is designed for the CR2032 button lithium battery. The bus socket is for connecting extension modules. The communication port PORT0 is RS-232 and uses socket Mini DIN8, while the communication port PORT1 is RS-485 or RS-232. The mode selector switch can be set to ON, TM or OFF.

1.2 AutoStation Programming Software

AutoStation is a programming software specialized for IVC1 and IVC2 series PLCs. You can download it at www.invt.com.cn.

The AutoStation software is a Windows-based diagram programming-tool, operated through the mouse and keyboard. Three programming languages are available: ladder diagram (LAD), instruction list (IL) and Sequential Function Chart (SFC).

To connect the AutoStation programming platform to your PLC, you can use directly the serial port programming cable, or the Modbus network through serial port conversion, or the Internet through a modem.

Refer to the *AutoStation Programming Software User Manual* for the Modbus programming and remote monitoring.

1.2.1 Basic Configuration

AutoStation programming software requires an IBM PC and Microsoft Windows series OS. The compatible OSs include Windows 98, Windows Me, NT 4.0, Windows 2000 and Windows XP.

The minimum and recommended configuration of the PC are listed below:

Table 1-2 Computer requirements

Item	Minimum	Recommended
CPU	Intel Pentium 233 equivalent or above	Intel Pentium 1G equivalent or above
Memory	64M	128M
Display card	Supportive of 640 × 480 resolution and 256 colors	Supportive of 800 × 600 resolution and 65535 colors
Communication port	A RS-232 serial port with DB9 socket (or a USB port and a USB-RS232 converter)	
Others	Invt dedicated PLC programming cable	

1.2.2 AutoStation Installation

The AutoStation installation package issued by Invt Auto-Control Technology Co., Ltd. (for short, Invt) is an executable program. Double click it to start the installation, and follow the prompts step by step. You can select an installation path according to your actual need.

After the installation, the **Invt Auto-Control Technology** program group will be added to the start menu. A AutoStation shortcut icon will also be added to the desktop.

You can uninstall the AutoStation software through the Windows **Control Panel**. To install a new version AutoStation, you have to uninstall the present version first.

1.2.3 AutoStation Operation Interface

The main interfaces include 7 sections: **Menu**, **Tool bar**, **Project Manager** window, **Instruction Tree** window, **Information** window, **Status bar** and **Operation area**.

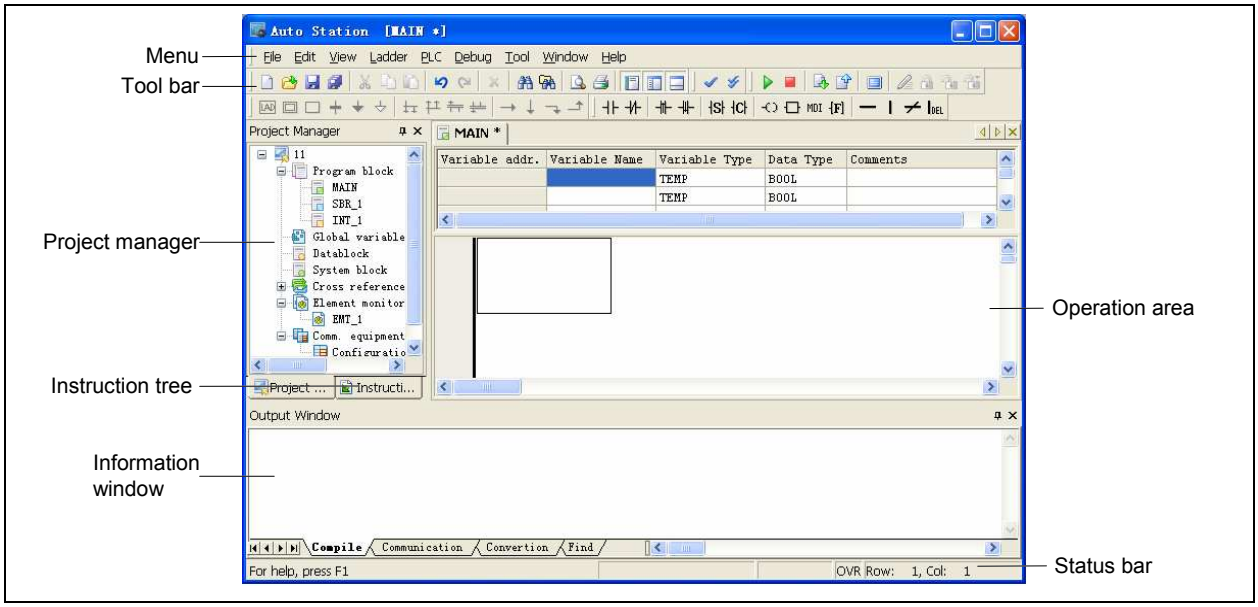


Figure 1-3 AutoStation main interface

For the usage of AutoStation programming software, refer to the *AutoStation Programming Software User Manual*.

1.2.4 Programming Cable

You can use the Invt dedicated programming cable to program and debug the PLC. Note that there are two kinds of cables, one being optically isolated and hot swappable; the other being non-isolated and not hot swappable. Neither of them requires setting jumpers.

See the following figure for the connection of the programming cable.

Figure 1-4 Connection of programming cable

1.3 Communication Function

Each IVC series PLC basic module has two integrated serial ports: PORT 0 and Port 1 . The Profibus and Canbus extension modules are also available for the communication in a fieldbus network.

The two serial ports of the basic module are compatible with Modbus, N:N bus and user-defined free port protocols.

1.3.1 Modbus Protocol Network

The basic module can set up a RS-485 Modbus network with multiple inverters, PLCs and other intelligent devices through the RS-485 on Port 1, or through Port 0 and a RS-232/485 converter. The maximum communication distance is 1200 meters, and maximum baud rate is 38400bit/s. RTU and ASCII transmission modes are optional.

The basic module can communicate one-to-one with inverters, PLCs, touch screens and meters through the RS-232 port on PORT 0 or Port 1 . The maximum communication distance is 15 meters; and maximum baud rate is 38400bit/s.

For details about the Modbus network, see *Chapter 10 Using Communication Function* and *Appendix 7 Modbus Communication Protocol (IVC Series)*.

1.3.2 N:N bus Protocol Network

The IVC1 series PLC is embedded with Invt-developed N:N bus communication protocol, capable of setting up an N : N communication network through the Port 1 RS-485 port, or through PORT 0 and a RS-232/485 converter.

The N:N bus communication protocol allows single/double-layer networking and data exchange among 2~32 PLCs with the maximum baud rate of 115200bps.

For details about the N:N bus network, see *Chapter 10 Using Communication Function*.

1.3.3 Free Port Protocol Network

The free port protocol allows communication with customized data format. It supports ASCII and binary system. In this communication mode, the PLC can communicate with various equipment with customized formats, such as inverter, bar-code scanner, instrument, and other intelligent devices. PLC can communicate with a single device in the RS-232 or RS-485 mode, or form a RS-485 network when there are multiple devices.

For details about the free port protocol communication, see *Chapter 10 Using Communication Function.*

1.4 Makeup Of Document System Of IVC Series Small PLCs

You can download the documents of IVC series small PLC at www.invt.com.cn. If you need the paper copy of the document, please contact your agent.

1.4.1 Model Selection Instruction

IVC1 Model Selection Manual
IVC2 Technical Manual

1.4.2 Basic Module User Manual

IVC1 series
IVC1 Series PLC Quick Start User Manual
IVC1 Series PLC User Manual

IVC2 series
IVC2 Basic Module Quick Start Manual
IVC2 *Series PLC User Manual*

1.4.3 Programming Manual

IVC Series Small PLC Programming Manual

1.4.4 Programming Software User Manual

AutoStation Programming Software User Manual

1.4.5 I/O Extension Module User Manual

IVC1 series
IVC1 Series PLC Passive I/O Extension Module User Manual

IVC2 series
IVC2 Series PLC Passive I/O Extension Module User Manual
IVC2 Series PLC Active I/O Extension Module User Manual

1.4.6 Special Module User Manual

IVC1 series
IVC1-4AD Analog Input Module User Manual
IVC1-4DA Analog Output Module User Manual
IVC1-4PT RTD Module User Manual
IVC1-4TC Thermalcouple Module User Manual
IVC1-5AM Analog Input/Output Module User Manual

IVC2-4AD Analog Signal Module User Manual
IVC2-4AM Analog Signal Input/Output Module User Manual
IVC2-4DA Analog Signal Output Module User Manual
IVC2-4LC Temperature Control Module User Manual
IVC2-4PT RTD Module User Manual
IVC2-4TC Thermocouple Module User Manual
IVC2-8AD Analog Input Module User Manual
IVC2-8TC Thermocouple Module User Manual

IVC2 series

Chapter 2 PLC Function Description

This chapter introduces the programming resources, theories and system configuration of IVC series PLC, as well as how to set PLC running and operation modes. The system commissioning functions and commissioning software are also introduced.

2.1 Programming Resources And Theories 9
2.1.1 Programming Resources 9
2.1.2 System Running Mechanism (Scan Cycle Model) 11
2.1.3 Watchdog Function For User Program Execution 11
2.1.4 Constant Scan Mode 11
2.1.5 User File Download And Storage 12
2.1.6 Initialization Of Elements 12
2.1.7 Saving Data On Power Loss 12
2.1.8 Permanent Storage Of D Device Data 13
2.1.9 Digital Filtering Of Input Terminals 13
2.1.10 No Battery Mode 13
2.1.11 User Program Protection 14
2.2 System Configuration 14
2.2.1 System Block 14
2.2.2 Datablock 21
2.2.3 Global Variable Table 21
2.2.4 Setting BFM For IVC2 Serie Special Module 22
2.3 Running Mode And State Control 22
2.3.1 System RUN And System STOP States 23
2.3.2 RUN & STOP State Change 23
2.3.3 Setting Output In STOP State 23
2.4 System Debugging 24
2.4.1 Uploading & Downloading Program 24
2.4.2 Error Reporting Mechanism 24
2.4.3 Editing User Program Online 26
2.4.4 Clearing And Formatting 26
2.4.5 Checking PLC Information Online 27
2.4.6 Write, Force And Element Monitoring Table 28
2.4.7 Generating Datablock From RAM 29

2.1 Programming Resources And Theories

2.1.1 Programming Resources

Table 2-1 IVC1 Programming resources

Item		Specification and remarks	
I/O configuration	Max. I/O points	128 (theoretical)	
	Externsion module number	<4 (sum of I/O extension modules and special modules)	
User file capacity	Program capacity	12k steps	
	Data block capacity	8000 D elements	
Instruction speed	Basic instruction	0.3μs/instruction	
	Application instruction	Several μs per instruction ~ several hundred μs per instruction	
Instruction number	Basic instruction	32	
	Application instruction	226	
Device configuration Note 7	I/O points	128 I/128 O (Input: X0 ~ X177. Output Y0 ~ Y177) Note 1	
	Auxiliary relay	2048 (M0 ~ M2047)	
	Local auxiliary relay	64 (LM0 ~ LM63)	
	Special auxiliary relay	256 (SM0 ~ SM255)	
	State relay	1024 (S0 ~ S1023)	
	Timer	256 (T0 ~ T255) Note 2	
	Counter	256 (C0 ~ C255) Note 3	
	Data register	8000 (D0 ~ D7999)	
	Local data register	64 (V0 ~ V63)	
	Offset addressing register	16 (Z0 ~ Z15)	
	Special data register	256 (SD0 ~ SD255)	
Interrupt configuration	External input interrupt	16 (triggering edge is user configurable, corresponding to the rising and falling edge s of terminals X0 ~ X7)	
	High speed counter interrupt	6	
	Internal timer interrupt	3	
	Serial port interrupt	8	
	PTO output complete interrupt	2	
	Power failure interrupt	1	
Communication function	Port	2 asynchronous serial communication ports. Port 0: RS-232. Port 1: RS-232 or RS-485	
	Protocol	Modbus, Freeport, N:N bus (Invt dedicated protocol). 1 to N or N to N communication enabled	
Special function	High speed counter	X0, X1	Single input: 50kHz. Total frequency (X0 ~ X5): < 80kHz
		X2 ~ X5	Single input: 10kHz
	High speed pulse output	Y0, Y1	100kHz (2 independent outputs, and only for transistor outputs)
	Digital filtering terminals	X0 ~ X7 (all the other terminals use hardware filtering)	
	Analog potentiometer Note 4	2	
	Subprogram	Maximum number: 64. Maximum nesting levels: 6. Local variables and variable alias are supported. Each subprogram can provide up to 16 parameter transfer	
	User program protection	Upload password	3 kinds of password. Not longer than 8 letters or numbers. Case sensitive
		Download password	
		Monitor password	
		Subprogram password	Not longer than 16 letters or numbers. Case sensitive.
		Other protections	Formatting and uploading ban enabled
	Programming mode Note 5	AutoStation programming software Note 6	IBM PC or compatible computer is required
	Real time clock	Built-in, 100h of working time after power failure (the basic module must have worked for more than 2mins before the power failure)	

Table 2-2 IVC2 programming resources

Name	Specification and remarks

Name		Specification and remarks	
I/O configuration	Max. I/O points	512 (256 I/256 O)	
	Externsion module number	<8 (sum of I/O extension modules and special modules)	
User file capacity	Program capacity	12k steps	
	Data block capacity	8000 D elements	
Instruction speed	Basic instruction	0.09μs/instruction	
	Application instruction	5μs/instruction ~ 280μs/instruction	
Instruction number	Basic instruction	32	
	Application instruction	221	
Device configuration Note 7	I/O points	256 I/256 O (Input: X0 ~ X377. Output: Y0 ~ Y377) Note 1	
	Auxiliary relay	2000 (M0 ~ M1999)	
	Local auxiliary relay	64 (LM0 ~ LM63)	
	Special auxiliary relay	256 (SM0 ~ SM255)	
	State relay	992 (S0 ~ S991)	
	Timer	256 (T0 ~ T255) Note 2	
	Counter	256 (C0 ~ C255) Note 3	
	Data register	8000 (D0 ~ D7999)	
	Local data register	64 (V0 ~ V63)	
	Offset addressing register	16 (Z0 ~ Z15)	
	Special data register	256 (SD0 ~ SD255)	
Interrupt configuration	External input interrupt	16 (triggering edge is user configurable, corresponding to the rising & falling edge s of terminals X0 ~ X7)	
	High speed counter interrupt	6	
	Internal timer interrupt	3	
Communication function	Port	2 asynchronous serial communication ports. Port 0: RS-232. Port 1: RS-232 or RS-485	
	Protocol	Modbus, Freeport. 1 to N communication enabled	
Special function	High speed counter	X0, X1	Single input: 50kHz. Total frequency (X0 ~ X5): < 80kHz
		X2 ~ X5	Single input: 10kHz
	High speed pulse output	Y0, Y1	100kHz (2 independent outputs, and only for transistor outputs)
	Digital filtering terminals	X0 ~ X17 (all the other terminals use hardware filtering)	
	Analog potentiometer Note 4	2	
	Calling of subprograms	Maximum number: 64. Maximum nesting levels: 6. Local variables and variable alias are supported. Each subprogram can provide up to 16 parameter transfer	
	User program protection	Upload password	3 kinds of password. Not longer than 8 letters or numbers. Case sensitive
		Download password	
		Monitor password	
	Programming mode Note 5	AutoStation programming software Note 6	IBM PC or compatible computer is required
	Real time clock	Built-in, powered by backup battery	

Notes:

Note 1: The X and Y elements are addressed in octal system. For example, X10 stands for the eighth input point.

Note 2: Based on the timing precision, the T device addresses fall into three categories:

1) 100ms: T0 ~ T209
2) 10ms: T210 ~ T251
3) 1ms: T252 ~ T255

Note 3: Based on the width and function of count value, the C device addresses fall into three categories:

1) 16 bit up counter: C0 ~ C199
2) 32 bit up and down counter: C200 ~ C235
3) 32 bit high speed counter: C236 ~ C255

Note 4: The analog potentiometer is an instrument that you can use to set the PLC device value.. You can use a Philips screw driver to wind the potentiometer clockwise to the maximum angle of 270°, and the device value will be set from 0 to 255. Note that the potentiometer could be damaged if you wind it clockwise more than 270°.

Note 5: The element values can be forcedly set to facilitate commissioning and analyzing user program and streamline the commissioning. You can force up to 128 bit elements and 16 word elements at the same time.

Note 6: The user program can be modified online.

Note 7: Partial PLC elements are reserved. Avoid using those elements in the user program. For details, see *Appendix 3 Reserved* Elements .

2.1.2 System Running Mechanism (Scan Cycle Model)

IVC series PLC basic module runs according to the scan cycle model.

The system cyclically executes the following four tasks one by one: user program execution, communication, internal tasks and I/O update. Each round is called a scan cycle.

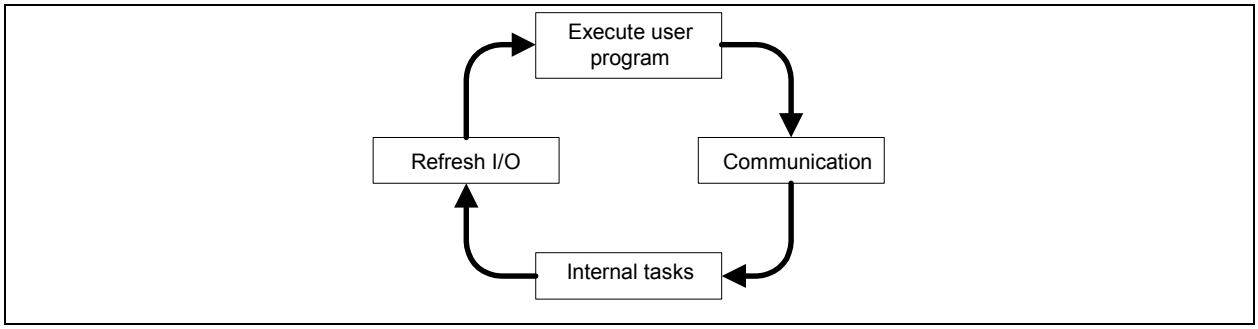


Figure 2-1 PLC operation mechanism

User program execution

The system will execute user program instructions one by one from the beginning till the main program ending instruction.

Communication

Communicate with the programming software to receive and respond to the instructions such as download, run and stop.

Internal tasks

Processing various system internal tasks, such as refreshing panel indicators, updating software timer, refreshing special auxiliary relays and special data registers.

I/O update

The I/O update includes two stages: input update and output update.

Output update: open or close the output terminal based on the value of the corresponding Y device (ON or OFF).

Input update: convert the ON or OFF state of input terminals to the value of the corresponding X device (ON or OFF).

2.1.3 Watchdog Function For User Program Execution

The watchdog function enables the system to monitor the user program execution time during every scan cycle, and stop the user program if the running time exceeds the preset limit. You can set the watchdog time in the **Set Time** tab after double clicking the **System block** in AutoStation main interface.

2.1.4 Constant Scan Mode

In the constant scan mode, every scan cycle takes the same time. You can set the constant scanning time in the **Set Time** tab after double clicking the **System block** in AutoStation main interface. By default, the **Constant scanning time setting** is zero, which means no constant scan. The actual scan cycle will prevail when the actual scan cycle is bigger than the constant scan cycle.

🕮 **Note**

The **Constant scanning time setting** must not be set bigger than the **Watchdog time setting**.

2.1.5 User File Download And Storage

You can download a user file to the basic module to control the basic module.

The user file include user program, data block, system block and auxiliary user information. The auxiliary user information include the user program variable list and the source file of user data.

You can select to download the user program, data block or system block. Whatever you select, the corresponding auxiliary user information will always be downloaded.

For IVC2 series PLC, the downloaded user program, data block and system block will be stored permanently in the basic module EEPROM area, while the downloaded auxiliary user information will be stored in the battery backed RAM area.

For IVC1 series PLC, all user files will be stored permanently in the basic module FLASH area.

🕮 **Note**

1. To embed the downloaded files into the basic module, the basic module power supply must be maintained for more than 30s after the download.
2. If the backup battery fails in IVC2 series PLC, the auxiliary user information will be lost, the annotation for the user program will not be uploaded, and system will report "User information file error"**.** But the user program will be executed after all.

2.1.6 Initialization Of Elements

When the PLC changes from STOP to RUN, it will initialize its elements according to battery backed data, EEPROM data, data block and device value. The priorities of various data are listed in the following table.

Table 2-3 PLC data initialization priorities

Data type	Power OFF → ON	STOP → RUN
Battery backed data	Highest	Highest
EEPROM data	High	High
Data block (precondition: the **Datablock enabled** is checked in the **Advanced Settings** tab of **System block**)	Mid	Mid
Device value (Precondition: the **Element value retained** is checked in the **Advanced Settings** tab of **System block**)	-	Low

2.1.7 Saving Data On Power Loss

Preconditions

Upon power loss, the system will stop the user program and save the device in the specified saving range to the battery backed files.

Device restoration after power on

If the battery backed files are correct, the PLC elements will restore their saved values after power on.

The elements outside of the saving range will be set to zero.

If the battery backed files are lost or incorrect, the system will set all elements to zero.

Setting saving range

You can set the device range in the **Saving Range** tab of **System block. See** Figure 2-2 and the following example.

IVC1 series PLC supports only one group of saving range.

IVC2 series PLC supports two saving groups that form a union.

Example (IVC2):

Set M100 ~ M200 as the saving range in **Group 1**.

Set M300 ~ M400 as the saving range in **Group 2**.

In effect, both M100 ~ M200 and M300 ~ M400 are set as the saving range.

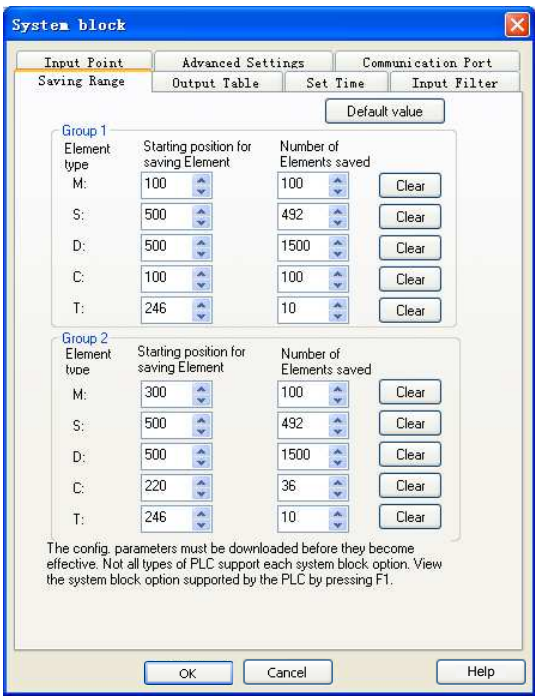


Figure 2-2 Setting saving range

Note

The power loss data saving function in IVC2 series PLC relies on the support of the backup battery. If batteries fail, all the saved elements will have uncertain values after power loss.

For IVC1 series PLC, the values of its saved elements are stored in the permanent memory.

2.1.8 Permanent Storage Of D Device Data

You can use the EROMWR instruction in the user program to write the D device values (D6000 ~ D6999) to the permanent memory EEPROM in IVC1 series PLC. The EEPROM operation will make the scan cycle 2ms ~ 5ms longer. The written data will overwrite the existing data in EEPROM.

Note

The EEPROM can be over-written for a limited number of times (usually one million). Do not overwrite EEPROM unless it is necessary, otherwise EEPROM could fail soon and lead to CPU fault.

2.1.9 Digital Filtering Of Input Terminals

The input terminals X0 ~ X17 of IVC2 series PLC and X0 ~ X7 of IVC1 series PLC use digital filtering to filter the noise at the terminal. You can set the filter constant in the **Input Filter** tab of **System block**.

The filter constant setting ranges are:

IVC2: 0 ~ 60ms. Default: 10ms.

IVC1: 0, 8, 16, 32 and 64ms. Default: 8ms.

2.1.10 No Battery Mode

The IVC2 series basic module can work without battery. When you select the **No battery mode** in the **Advanced Settings** tab of **System block**, the system will not report system errors caused by lack of battery (Battery-backed data lost, Forced-table lost and User information file error).

See the notice for the **No battery mode** in the **Advanced Settings** tab of **Data block**.

Note

IVC1 series PLC has no battery, therefore it does not support no battery mode.

2.1.11 User Program Protection

The IVC1 and IVC2 series PLCs provide mutiple levels of passwords and other protection measures.

Table 2-4 User program protection

Protection measures	Description
Formatting ban	After downloading system block to the PLC and checking the **Formatting is prohibited** option in the **Advanced Settings** tab in **System block**, the PLC internal user program, system block and data block are protected against formatting. To lift the formatting ban, you need to re-download the system block and uncheck the **Formatting is prohibited** option
Download password	Download limit
Upload ban	If you select to disable the upload function during downloading process, it will be prohibited to upload the program from PLC to PC. To enable the upload function, you must re-download the program and check to enable the upload function during the downloading process.
Upload password	Upload limit
Monitor password	Monitor limit
Program password	The programmer can set passwords to protect the program, subprogram and interrupt subprogram against aunthrorized accessing and editing in AutoStation. Password setting method: Right click the program and select **Encrypt/Decrypt** in the popped out shortcut menu, insert the password and confirm it. To cancel the password, just go through the same process and input the correct password.

🕮 **Note**

If you fail to input the correct password for continuously ten times, you will be banned from inputting password for the next 5 minutes.

2.2 System Configuration

2.2.1 System Block

The PLC configuration information, or system block file, is configured through the system block and is an important part of the PLC user file. Before using the PLC, you need to compile and download the system block file.

The system block configuration includes configuring the following items:

- **Saving Range** (element saving range)
- **Communication Port** (Communication port and protocol setting)
- **Input Filter**
- **Output Table**
- **Set Time** (set watchdog time and constant scanning time)
- **Input Point** (Startup mode of the input point)
- **Priority Level Of Interruption**
- **Special Module Configuration**
- **Advanced Settings** (data block, element value retain, no battery mode and formatting ban)

After setting the system block, you can select **PLC**-> **Compile All** to compile the system block file and be ready for download.

Saving Range

Upon power loss, the IVC1 and IVC2 series PLCs can save the data of elements in the preset saving range to SRAM, so as to use them after the power on.

You can set the saving range in the **Saving Range** tab, as shown in *Figure 2-3.*

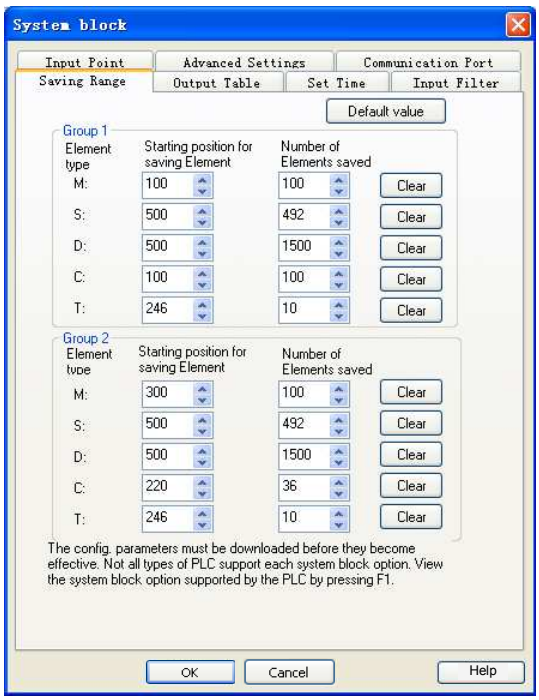


Figure 2-3 Setting element saving range

Note

The element range and group number of the saving range are different for different PLC models.

By default, the D, M, S, T and C elements in a certain range will be saved.

You can change the defaults as you need. By clicking the **Clear** button on the right will set the corresponding number to zero.

For IVC2 series PLC, you can set two groups that form a union.

For IVC1 series PLC, you can set only one group.

Note

The T elements cannot be set in the saving range for IVC1 series PLC.

System operation upon power loss: PLC will save the elements in the saving range to the battery backed files.

System operation upon power on: PLC will check the data in SRAM. If the data saved in SRAM is correct, it will remain unchanged. If the data is incorrect, PLC will clear all the elements in SRAM.

Communication Port

You can set the two PLC communication ports in the **Communication Port** tab of the **System block,** as shown in *Figure 2-4***.** The items include protocol selection and setting the specific protocol parameters.

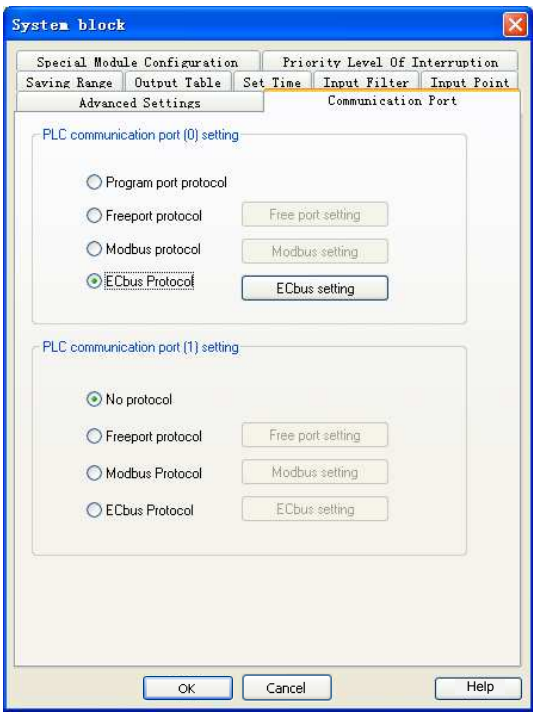


Figure 2-4 Setting communication ports

By default, the communication port 0 uses program port protocol, while the communication port 1 uses no protocol. You can set as you need.

1. Program port protocol

By default, the communication port 0 uses the program port protocol, the dedicated protocol for the communication of IVC series PLC programming software. Under this protocol, you can set the communication baud rate between PC and port 0 through the serial port configuration tool of AutoStation. In the TM state, port 0 can only be used for programming communication.

2. Free port protocol

The free port protocol supports customized data file format, either ASCII or binary code. Only in the RUN state can a PLC use the free port communication, which cannot be used to communicate with the programming device. In the STOP state, port 0 can only be used for programming communication.

The configurable parameters include **Baud rate**, **Data bit**, **Valid bit**, **Parity**, **Stop bit**, **Allow start character detection**, **Allow end character detection**, **Intercharacter timeout** and **Interframe timeout**.

3. Modbus protocol

The Modbus communication equipment include a master and a slave. The master can communicate with the slave (including inverters) and send control frames to the slave, and the slave will respond to the master's requests.

Communication port 0 can be set as a slave, while communication port 1 can be set as a slave or a master.

The configurable parameters include **Baud rate**, **Data bit**, **Parity check**, **Stop bit**, **master/slave mode**, **Station no.**, **Transmission mode**, **Timeout time of the main mode** and **Retry times**.

4. N:N bus protocol

N:N bus is an Invt-developed communication protocol that supports N to N communication in a small PLC network. The PLCs in a N:N bus network can automatically exchange part of their D and M elements.

Both port 0 and port 1 can use N:N bus protocol.

Note

For the detailed information of communication protocols, see *Chapter 10 Using Communication Function*.

Input Filter

In the Input Filter tab, you can set the filter constant for a PLC input terminal. The digital filter can eliminate the noise at the input terminal. Only input terminals X0 ~ X17 (for IVC1 series: X0 ~ X7) use digital filter, while other digital input terminal use hardware filter. See Figure 2-5.

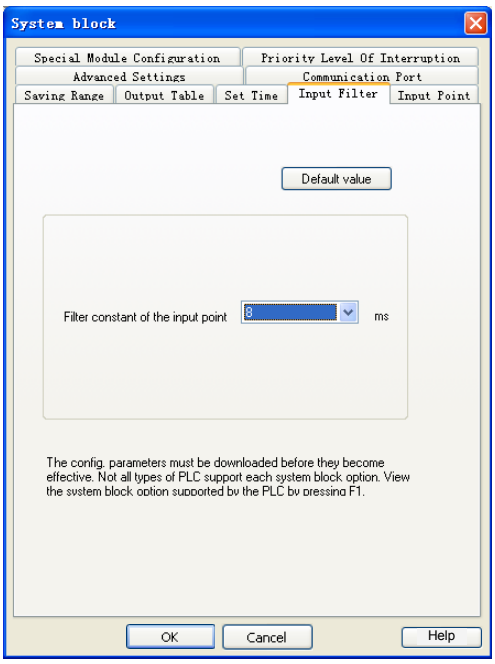


Figure 2-5 Setting input filter

IVC2 setting range: 0ms ~ 60ms. Default: 10ms.

IVC1 setting range: 0ms, 8ms, 16ms, 32ms, 64ms. Default: 8ms.

Output Table

In the **Output Table** tab, you can set the state of output points when the PLC is in STOP state. See Figure 2-6.

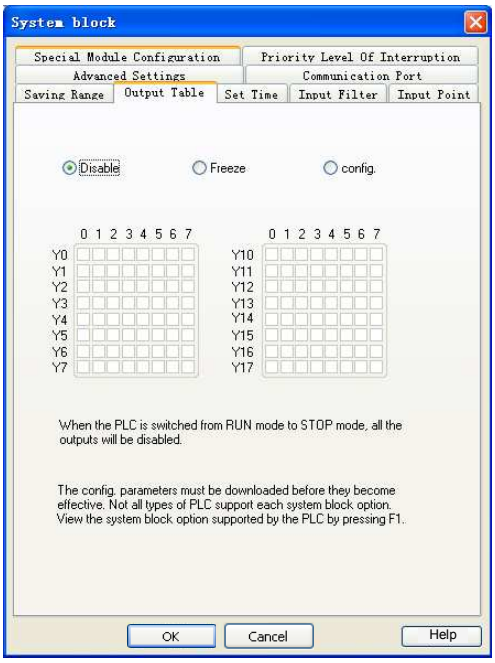


Figure 2-6 Setting output table

The output table is used to set the PLC output state when the PLC is stopped. The output states include:

(1) Disable: When the PLC is stopped, all the outputs will be disabled.

(2) Freeze: When the PLC is stopped, all the outputs will be frozen at the last status.

(3) Configure: When the PLC is stopped, the marked outputs will be set as ON.

Set Time

See Figure 2-7.

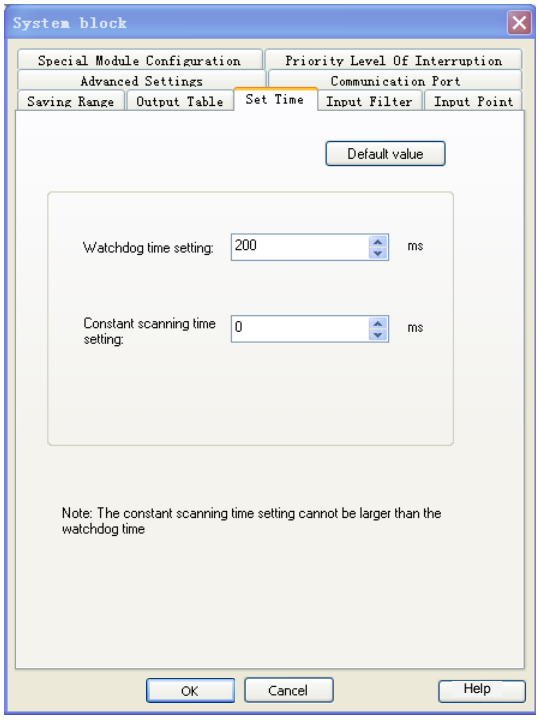


Figure 2-7 Setting time

1. Watchdog time setting

The watchdog time is the maximum user program execution time. When the actual program execution time exceeds the watchdog time, PLC will stop the execution, the ERR indicator (red) will turn on, and the system will output according to the system configuration. The watchdog time setting range is 0ms ~ 1000ms. Default: 200 ms.

2. Constant scanning time setting

With the constant scanning time set, system will scan the registers within a constant duration. Setting range: 0ms ~ 1000ms. Default: 0ms.

3. Power loss detection time setting (for IVC2 only)

When the duration of power loss exceeds the power loss detection time, the PLC will change to STOP. The system will save the values of elements in the Saving Range. Setting range: 0ms ~ 100ms. Default: 0ms

Input Point

The **Input Point** setting tab is shown in Figure 2-8.

In this tab, you can set the following parameters:

1. **Disable input point**

Check the **Disable input point** to disable the input point startup function.

2. **Input point**

When the **Disable input point** is not checked, you can designate an input terminal (among X0 ~ X17) as a means of external RUN control. When the designated input terminal is ON, the PLC will be turned from STOP state to RUN state.

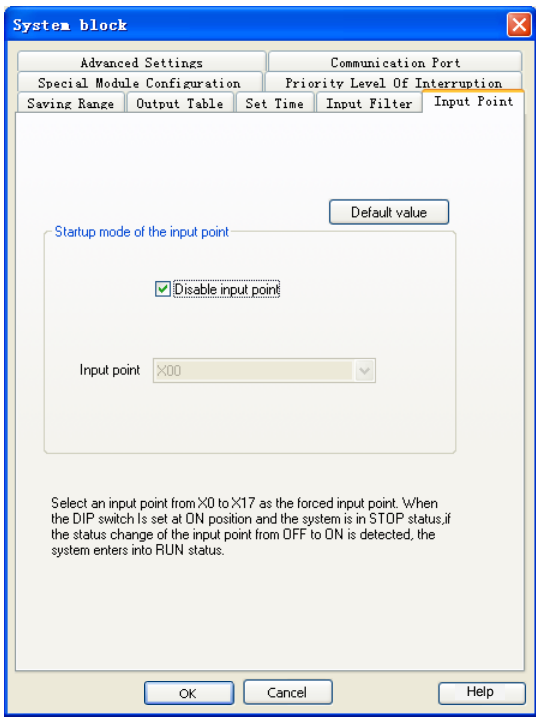

System block
Advanced Settings
Communication Port
Special Module Configuration
Priority Level Of Interruption
Saving Range
Output Table
Set Time
Input Filter
Input Point
Default value
Startup mode of the input point
Disable input point
Input point
X00
Select an input point from X0 to X17 as the forced input point. When the DIP switch is set at ON position and the system is in STOP status,if the status change of the input point from OFF to ON is detected, the system enters into RUN status.
OK
Cancel
Help

Figure 2-8 Setting input point

Priority Level Of Interruption

The **Priority Level Of Interruption is shown in Figure 2-9.**

The PLC built-in interrupts can be set as high priority or low priority.

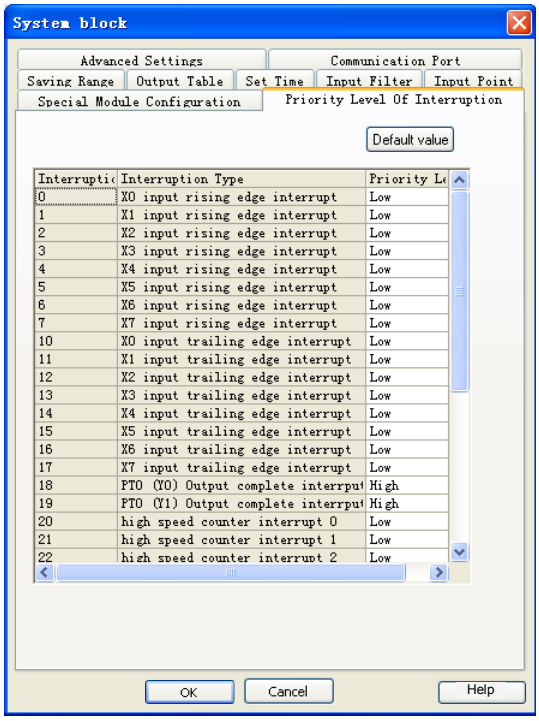

System block
Advanced Settings
Communication Port
Saving Range
Output Table
Set Time
Input Filter
Input Point
Special Module Configuration
Priority Level Of Interruption
Default value
Interrupti
Interruption Type
Priority Le
0 X0 input rising edge interrupt Low
1 X1 input rising edge interrupt Low
2 X2 input rising edge interrupt Low
3 X3 input rising edge interrupt Low
4 X4 input rising edge interrupt Low
5 X5 input rising edge interrupt Low
6 X6 input rising edge interrupt Low
7 X7 input rising edge interrupt Low
10 X0 input trailing edge interrupt Low
11 X1 input trailing edge interrupt Low
12 X2 input trailing edge interrupt Low
13 X3 input trailing edge interrupt Low
14 X4 input trailing edge interrupt Low
15 X5 input trailing edge interrupt Low
16 X6 input trailing edge interrupt Low
17 X7 input trailing edge interrupt Low
18 PTO (Y0) Output complete interrput High
19 PTO (Y1) Output complete interrput High
20 high speed counter interrupt 0 Low
21 high speed counter interrupt 1 Low
22 high speed counter interrupt 2 Low
OK
Cancel
Help

Figure 2-9 Setting interrupt priority

Special Module Configuration

You can set the **Module Type** and **Module Property** in the **Special Module Configuration** tab, as shown in Figure 2-10.

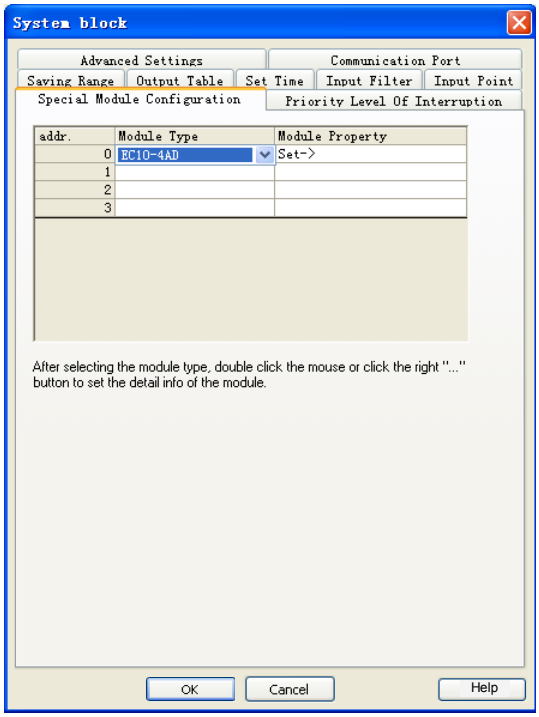


Figure 2-10 Setting special module

1. Module Type

As shown in Figure 2-10, you can set the module type for No.0 ~ No.3 special modules.

Module Property

After selecting the **Module Type**, the corresponding **Module Property** will be activated. Open the dialogue box as shown below.

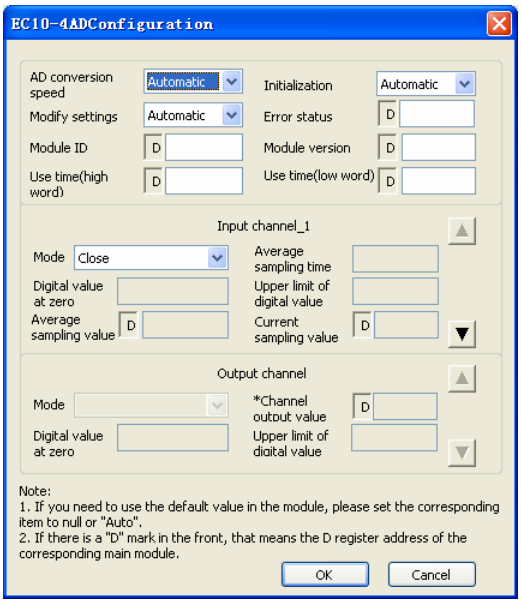


Figure 2-11 Setting special module property

In the dialogue box as shown in Figure 2-11, you can configure the channel for the special module, including **Mode** (signal features), **Digital value at zero**, **Upper limit of digital value**, and **Average sampling value**. Refer to the user manual of the specific special module for the meanings and configuration methods of the various parameters.

Advanced Settings

The advanced settings include **Datablock enabled**, **Element value retained**, **No battery mode** and **Formatting is prohibited**.

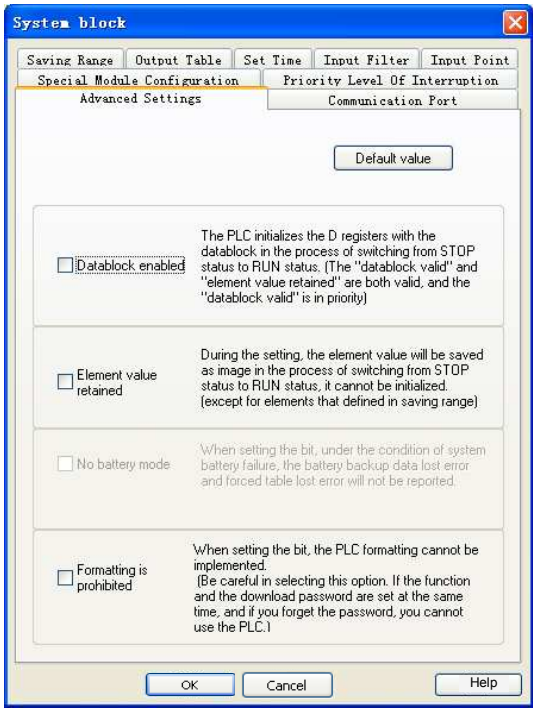

System block
Saving Range
Output Table
Set Time
Input Filter
Input Point
Special Module Configuration
Priority Level Of Interruption
Advanced Settings
Communication Port
Default value
Datablock enabled
The PLC initializes the D registers with the datablock in the process of switching from STOP status to RUN status. (The "datablock valid" and "element value retained" are both valid, and the "datablock valid" is in priority)
Element value retained
During the setting, the element value will be saved as image in the process of switching from STOP status to RUN status, it cannot be initialized. (except for elements that defined in saving range)
No battery mode
When setting the bit, under the condition of system battery failure, the battery backup data lost error and forced table lost error will not be reported.
Formatting is prohibited
When setting the bit, the PLC formatting cannot be implemented. (Be careful in selecting this option. If the function and the download password are set at the same time, and if you forget the password, you cannot use the PLC.)
OK
Cancel
Help

Figure 2-12 Advanced settings

Datablock enabled

Check the **Datablock enabled**, and the datablock will be used to initialize the D elements when the PLC changes from STOP to RUN.

Element value retained

Check the **Element value retained**, and the elements will not be initialized, but saved when the PLC changes from STOP to RUN.

Note

When the **Datablock enabled** and **Element value retained** are both checked, the **Datablock enabled** prevails. See *2.1.6 Initialization Of Elements*.

No battery mode

Check this option, and the system will not report the battery backup data lost error and forced table lost error upon battery failure.

2.2.2 Datablock

The datablock is used to set the defaults for D elements. If you download the compiled datablock settings to the PLC, the PLC will use the datablock to initialize the related D elements upon PLC startup.

The datablock editor enables you to assign initial data to the D register (data memory). You can assign data to words or double words, but not to bytes. You can also add comments by inputting "//" to the front of a character string.

See *AutoStation Programming Software User Manual* for detailed datablock instruction.

2.2.3 Global Variable Table

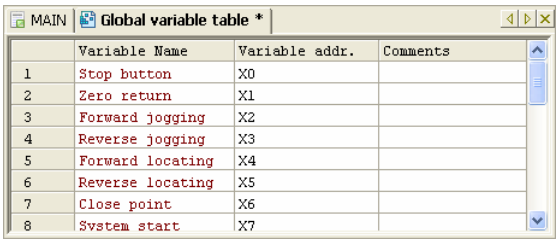
The global variables table enables you to give meaningful names for certain PLC addresses. The names are accessible anywhere in the project, and using them is in effect using the corresponding device.

The global variable

The global variable table includes three columns: **Variable Name**, **Variable addr**. and **Comments**.

The variable name can be made up of letters (case insensitive), numbers, underline or their mixture, but no spaces. The name cannot start with a number, nor be completely made up of numbers. Length: not longer than 8 bytes. The format of “device type + number” is illegal. No keywords shall be used. The keywords include: basic data type, instructions and the operators in the IL programming language.

The number of global variables shall not exceed 500. See Figure 2-13.


MAIN | Global variable table *

	Variable Name	Variable addr.	Comments
1	Stop button	X0	
2	Zero return	X1	
3	Forward jogging	X2	
4	Reverse jogging	X3	
5	Forward locating	X4	
6	Reverse locating	X5	
7	Close point	X6	
8	System start	X7	

Figure 2-13 Global variable table

2.2.4 Setting BFM For IVC2 Serie Special Module

There is no need to set the addresses for IVC2 series special modules, for the basic module can detect and address them automatically upon power on.

Among the special modules, the analog extension module includes the analog input module and analog output module.

The parameters of these two special modules, such as the channel characteristics, zero point and maximum digital signal are by default applicable directly. However, when necessary, you can change the parameters in order to cater for your actual needs.

IVC2 analog input module

IVC2 analog input module exchanges information with its basic module through the BFM area.

When a user program runs on the basic module, the TO instruction will write data to the related registers in the BFM area of IVC2 special module, and change the default settings. The configuration data that can be changed includes zero digital signal, maximum digital signal, input channel signal characteristic, input channel ready flag, and so on.

The basic module uses the FROM instruction to read the data from the BFM area of IVC2 analog input module. The data may include the analog-digital conversion result and other information.

IVC2 analog output module

IVC2 analog output module exchanges information with its basic module through the BFM area.

When a user program runs on the basic module, the TO instruction will write data to the related registers in the BFM area of IVC2 special module, and change the default settings. The configuration data that can be changed includes zero digital signal, maximum digital signal, output channel signal characteristic, output channel ready flag, and so on.

The basic module uses the FROM instruction to read the data from, and uses the TO instruction to write the digital signal to be convertered to, the BFM area of IVC2 analog output module.

For details about the TO/FROM instruction, refer to *Chapter 6 Application Instructions*. As for the information about various special modules, as well as their BFM areas, see the quick start manuals of the special module.

2.3 Running Mode And State Control

You can start or stop the PLC in any of the following three ways.

1. Using the mode selection switch
2. Feeding power to the designated input terminal (see **Input Point** in *2.2.1 System Block*)
3. Programming software (by clicking **PLC** -> **Stop** in the main interface if the mode selection switch is set as TM or ON)

2.3.1 System RUN And System STOP States

The basic module states include RUN state and stop state.

RUN

When the basic module is in the RUN state, the PLC will execute the user program. That is to say, all the four tasks in a scan cycle, namely the user program execution, communication, internal tasks and I/O update, will be executed.

STOP

When the basic module is in the STOP state, the PLC will not execute the user program, but will still execute the other three tasks in every scan cycle, namely the communication, internal tasks and I/O update.

2.3.2 RUN & STOP State Change

How to change from STOP to RUN

1. Resetting the PLC

If the mode selection switch is set to ON, reset the PLC (including power-on reset), and the system will enter the RUN state automatically.

📖 **Note**

If the **Disable input point** is not checked in the basic module system block, the corresponding input terminal must be ON, or the system will not enter the RUN state after reset.

2. Setting mode selection switch

When the PLC is in STOP state, setting the mode selection switch to ON will change the PLC to RUN state.

3. Powering the designated input terminal

If the **Disable input point** is not checked in the basic module system block, feeding power to the designated input terminal will change the PLC from STOP state to RUN state.

📖 **Note**

The mode selection switch must be set to ON for the input terminal startup mode to be valid.

How to change from RUN to STOP

1. Resetting the PLC

If the mode selection switch is set to OFF or TM, resetting the system (including power-on reset) will change the PLC to STOP state.

📖 **Note**

Even when the mode selection switch is ON, the system will also enter the STOP state after reset if the **Disable input point** is not checked in the basic module system block and the designated input point is OFF.

2. Setting mode selection switch

The system will change from RUN to STOP when you set the mode selection switch from ON or TM to OFF.

3. Using the STOP command

The system will enter the STOP state after executing the STOP command in the user program.

4. Auto-stop upon faults

The system will stop executing the user program when a serious fault (like user program error, or user program execution overtime) is detected.

2.3.3 Setting Output In STOP State

You can set the state of output terminals (Y) when the PLC is stopped. The three optional settings include:

1. Disable: When the PLC is stopped, all output terminals will be OFF.

2. Freeze: When the PLC is stopped, all the output terminals will be frozen at the last status.

3. Configure: You can decide which output will be ON and which will be OFF when the PLS is stopped according to the actual need.

You can find the above settings in the **Output Table** tab of the **System block**. See the *Output Table* in *2.2.1 System Block*.

2.4 System Debugging

2.4.1 Uploading & Downloading Program

Downloading

The system block, data block and user program edited in AutoStation can be downloaded to the PLC through a serial port. Note that the PLC should be in the STOP state when downloading.

If you change a compiled program and want to download it, the system will ask you to compile it again, as shown in Figure 2-14.

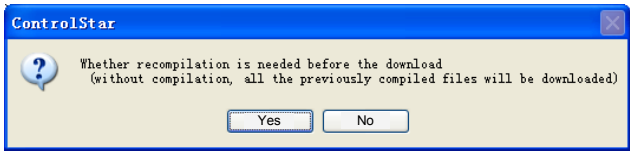

ControlStar
Whether recompilation is needed before the download
(without compilation, all the previously compiled files will be downloaded)
Yes
No

Figure 2-14 Re-compile prompt

Note

If you select No, the program compiled last time will be downloaded to the PLC, which means the changes are invalid.

If you have set a download password and have not entered it after starting the AutoStation this time, a window asking you to enter the password will pop up before the download can start.

Uploading

You can upload the system block, data block and user program from a PLC to your PC, and save them in a new project. If the battery backed data are valid, the user auxiliary information files will be uploaded together. See Figure 2-15.

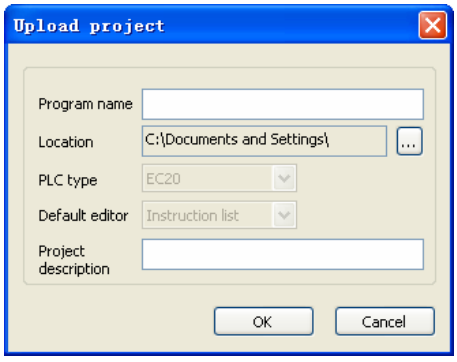


Figure 2-15 Upload dialogue box

If you have set a upload password and have not entered it after starting the AutoStation this time, a window asking you to enter the password will pop up before the upload can start.

During the download, you can select to disable the upload function, which means no PC can upload the program from the PLC. To enable the upload function, you must re-download the program and check to enable the upload function during the downloading process.

2.4.2 Error Reporting Mechanism

The system can detect and report two types of errors: system error and user program execution error.

A system error is caused by abnormal system operation. While a user program execution error is caused by the abnormal execution of the user program.

Every error is assigned with a code. See *Appendix 6 System Error Code*.

System error

When system error occurs, the system will set the special relay SM3, and write the error code into the special data register SD3. You can obtain the system error information by accessing the error code stored in SD3.

If multiple system errors occur at the same time, the system will only write the code of the worst error into SD3.

When serious system errors occur, the user program will halt, and the ERR indicator on the basic module will turn on.

User program execution error

When user program execution error occurs, the system will set the special relay SM20, and write the error code into the special data register SD20.

If the next application instruction is correctly executed, the SM20 will be reset, while SD20 will still keep the error code.

The system keeps the codes of the lastest five errors in special data registers SD20 ~ SD24 and form a stack.

If the code of the current error is different from the code in SD20, the error stack will be pushed down, as shown in Figure 2-16.

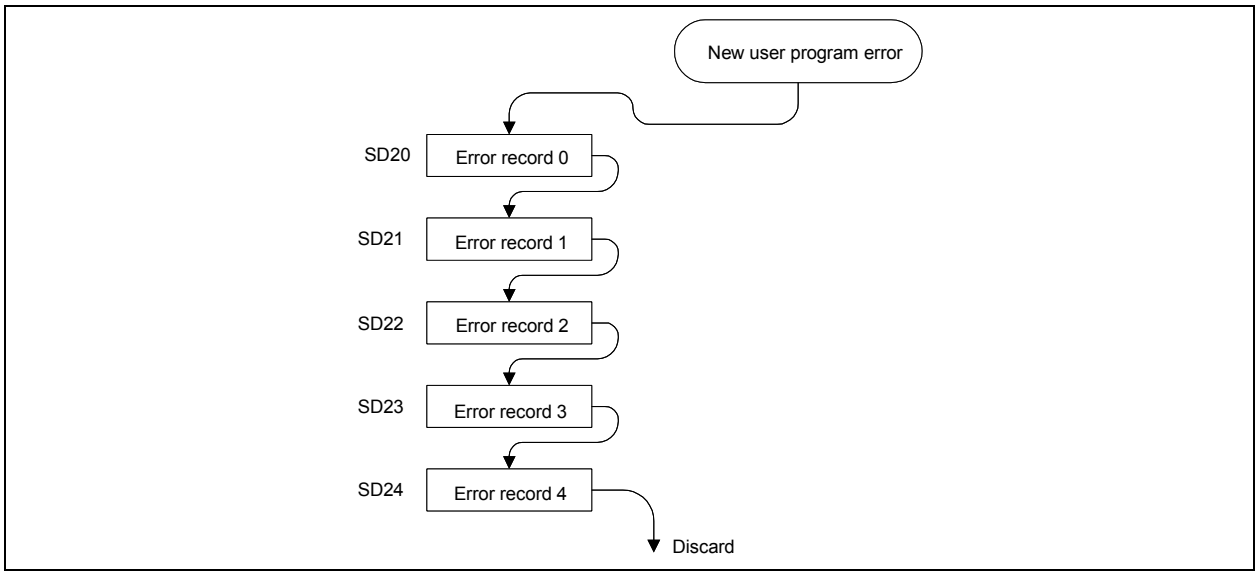


Figure 2-16 Push operation of the error stack

Only when serious user program execution error occurs will the user program halt and the ERR indicator on the basic module turn on. In less serious cases, the ERR indicator on the basic module will not turn on.

Checing the error information on-line

Connect the PLC with your PC through the serial port, and you can read various PLC state information through the AutoStation, including the system error and user program execution error.

In the main interface of AutoStation, click **PLC** -> **PLC Info…** to check the PLC information, as shown below:

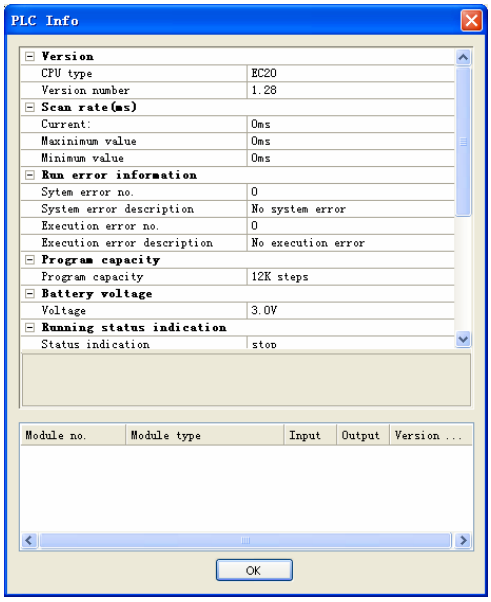


Figure 2-17 PLC information

The **System error no.** is the No. of the system errors stored in SD3, and **Execution error no.** is the No. of the execution error stored in SD20. The error description is for your reference.

2.4.3 Editing User Program Online

You can use the online edit function when you want to change the user program without stopping the PLC.

> 🕮 **Warning**
>
> On occasions when casualties or property loss may occur, the online program editing function should be used by professionals with sufficient protection measures.

Method

After making sure that the PC-PLC communication has been setup and the PLC is in RUN state, click **Debug** -> **Online Edit** in the AutoStation main interface to enter the online edit state.

In the online edit state, you can edit the main program, subprograms and interrupts as usual. After the edit, click **PLC** -> **Download…** and the edited program will be compiled and downloaded to the PLC automatically. When the download completes, the PLC will execute the new program.

Limits

1. In the online edit state, you cannot change the global variable table or any local variable table, nor add or delete any subprogram and interrupt.
2. AutoStation will quit the online edit state if the PLC is stopped.

2.4.4 Clearing And Formatting

You can use the clearing operation to clear PLC element value, PLC program and PLC datablock. While through formatting, you can clear all PLC internal data and program.

PLC Element Value Clear

The **PLC Element Value Clear** function can clear all element values when the PLC is in STOP state.

Think it twice before using the clearing function, because clearing PLC element values may cause PLC operation error or loss of working data.

PLC Program Clear

The **PLC Program Clear** function can clear the PLC user program when the PLC is in STOP state.

Think it twice before using the clearing function, because after the PLC user program is cleared, the PLC will have no program to execute.

PLC Datablock Clear

The **PLC Datablock Clear** function can clear all the PLC datablocks when the PLC is in STOP state.

Think it twice before using the clearing function, because after the PLC datablock is cleared, the PLC will not initialize element D according to the presetting of the datablock.

PLC Format

The PLC Format function can format all PLC data, including clearing the user program, restoring the defaults, and clearing the datablock (when PLC is in STOP state).

Think it twice before using the formatting function, because this operation will clear all the downloads and settings in the PLC.

2.4.5 Checking PLC Information Online

PLC Info…

The **PLC Info…** function can obtain and display various PLC running information, as shown in *Figure 2-18*.

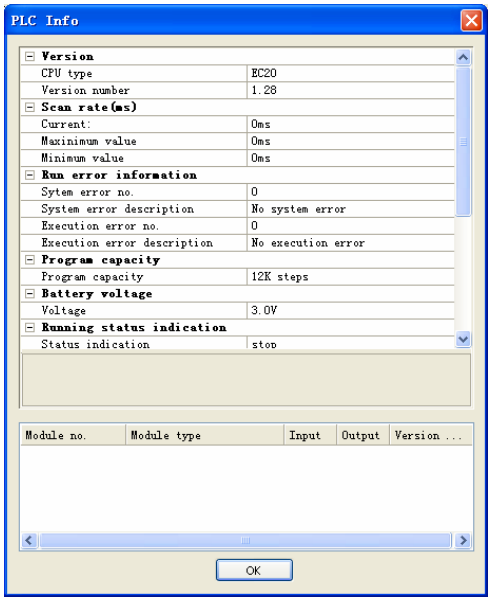


Figure 2-18 PLC current operation information

PLC Clock

The **PLC Clock** function can be used to display and set PLC present time, as shown in *Figure 2-19.*

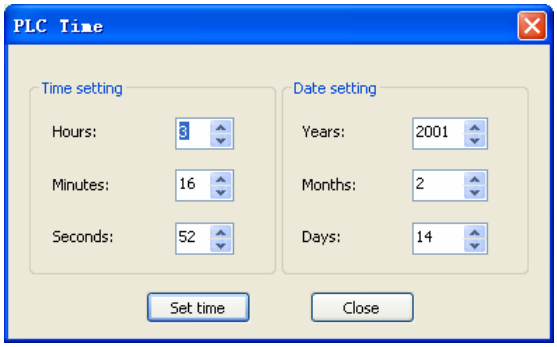


Figure 2-19 Setting PLC clock

Displayed in the **PLC Clock** window is the present date and time of PLC. You can adjust the time setting and click the **Set time** button to validate it.

2.4.6 Write, Force And Element Monitoring Table

Write and force

During the debugging, some element values may need to be changed manually. You can use the write or force function. Difference between write and force is that written element values are one-off and may change with the program operation, but forced element values will be permanently recorded in the PLC hardware until being unforced.

To use the write or force function, just select the element that needs changing, right click and select **Write Selected Element** or **Force…**. All the element addresses used by the selected element will be listed in the dialog box. Modify the address value to be written or forced, click the **OK** button, and the value will be downloaded to the PLC. If these values are effective in the hardware, you will see the change in later debugging process.

The **Write element value** dialogue box is shown in Figure 2-20:

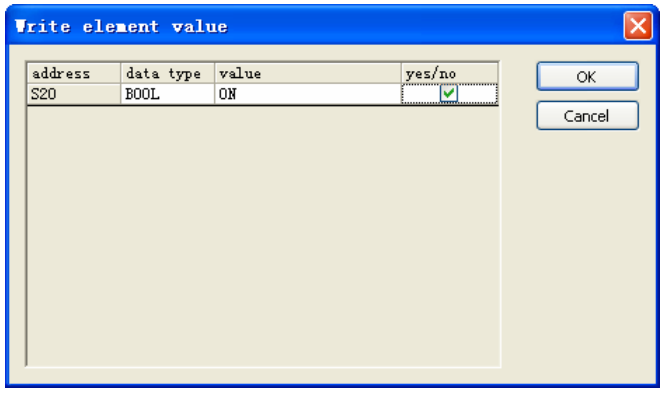


Figure 2-20 Write element value

The **Force element** dialogue box is shown in Figure 2-21:

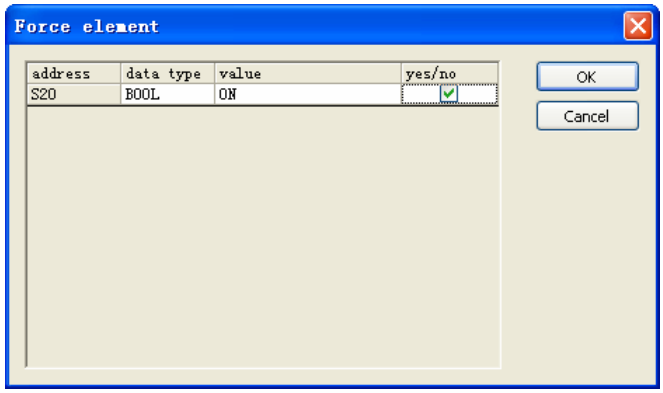


Figure 2-21 Force element

You can see a lock under the forced elements in the LAD, as shown in Figure 2-22:

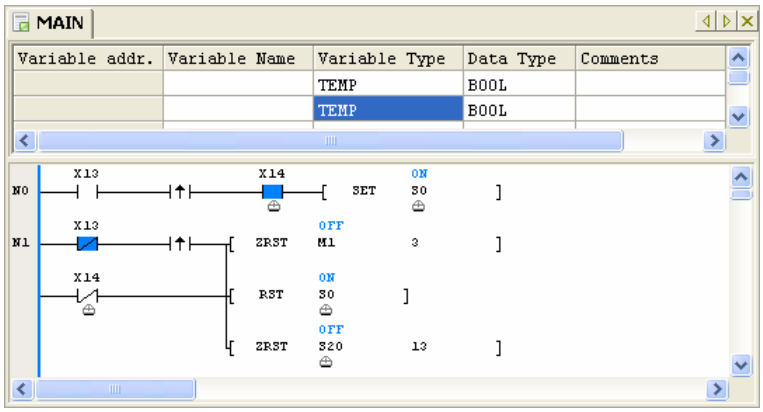


Figure 2-22 Lock signs under forced elements

Unforce

You can unforce any forced elements when forcing them becomes unnecessary. To unforce an element, select the target element, right click and select **Unforce** to pop up a dialog box as shown in Figure 2-23. All the forced elements among the selected elements are listed in the dialog box. You can select to unforce any elements, and click the **OK** button to confirm. The forced value will be deleted from the PLC, so is the lock mark.

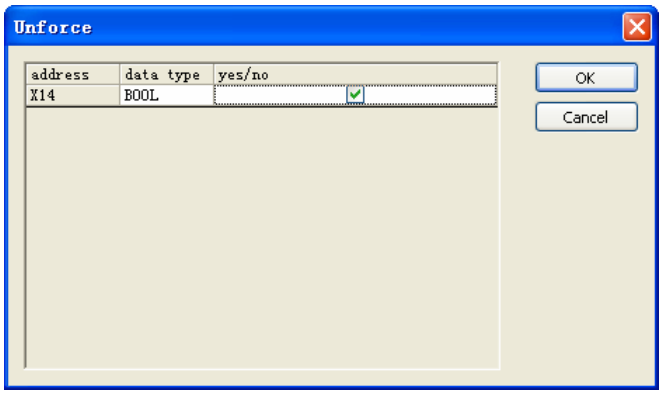


Figure 2-23 Unforce

Element monitoring table

The element monitoring table (EMT) is responsible for monitoring the element value during the debugging. the program input and output elements can be added to the EMT so that they can be tracked after the program is downloaded to the PLC.

The EMT monitors the element value during the debugging. You can input the input & output elements, registers and word elements into the EMT during the debugging so that those elements can be monitored after the program is downloaded to PLC.

The EMT works in two modes: editing mode and monitoring mode. In the editing mode, no monitoring function can be carried out. In the monitoring mode, both the monitoring and editing functions are available.

In the monitoring mode, the displayed elements' values are updated automatically.

The EMT provides functions including editing, sequencing, searching, auto-updating of the current value, written value, forced value of the specified element or variant, and unforce.

See Figure 2-24 for the illustration of an EMT:

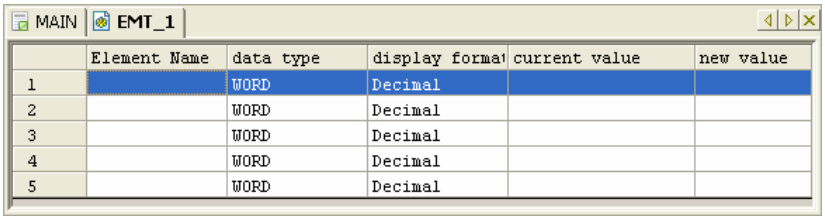


Figure 2-24 Element monitoring table

2.4.7 Generating Datablock From RAM

This function can continuously read and display the value of up to 500 D registers in the PLC. The results can merge into the datablock or overwrite the original datablock.

Select **PLC -> Generate Datablock From RAM…** to pop up a window as shown in Figure 2-25.

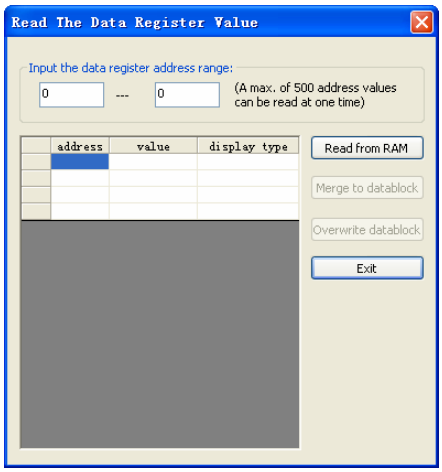


Figure 2-25 Reading data register value

Enter the range of the datablock to be read, click the **Read from RAM** button, and the data will be read into the list after the instruction is correctly executed.

You can select hex, decimal or octal or binary system in the field of **Display type** to display the data.

After reading the data successfully, the buttons of **Merge to datablock** and **Overwrite datablock** are enabled. Clicking **Merge to datablock** will add the results after the current datablock. Clicking **Overwrite datablock** will replace the contents in the datablock with the generated results. After exiting the register value reading window, the software will prompt that the datablock has changed and the datablock window will be opened automatically.

Chapter 3 Element And Data

This chapter details the description, classification and functions of the elements of IVC series small PLC.

3.1 Element Type And Function 32
3.1.1 What Is A PLC Element 32
3.1.2 Element List 33
3.1.3 Input And Output Points 34
3.1.4 Auxiliary Relays 35
3.1.5 State Relays 35
3.1.6 Timer 36
3.1.7 Counter 37
3.1.8 Data Register 37
3.1.9 Special Auxiliary Relay 38
3.1.10 Special Data Register 38
3.1.11 Offset Addressing Register 39
3.1.12 Local Auxiliary Relay 39
3.1.13 Local Data Register 39
3.2 Elements Addressing Mode 40
3.2.1 Kn Addressing Mode (Combined Bit-string Addressing Mode) 40
3.2.2 Z Addressing Mode (Offset Addressing Mode) 40
3.2.3 Kn Addressing In Combination With Z Addressing 41
3.2.4 Storing & Addressing 32-Bit Data In D & V Elements 41
3.3 Data 42
3.3.1 Data Type 42
3.3.2 Correlation Between Elements And Data Types 42
3.3.3 Constant 43

3.1 Element Type And Function

3.1.1 What Is A PLC Element

The PLC elements are virtual elements configured in PLC system design in order to replace the actual relays in the relay control circuits. PLC uses the elements to calculate and configure system function. Due to their virtual nature, the elements can be used repeatedly in the program, their number is in theory unlimited (only related to program capacity), and have no mechanical or electric problems like their actual counterparts. Such features make the PLC much more reliable than relay control circuits. In addition, it is easier to program and modify the logic.

The types and functions of IVC series PLC elements are shown in the following figure.

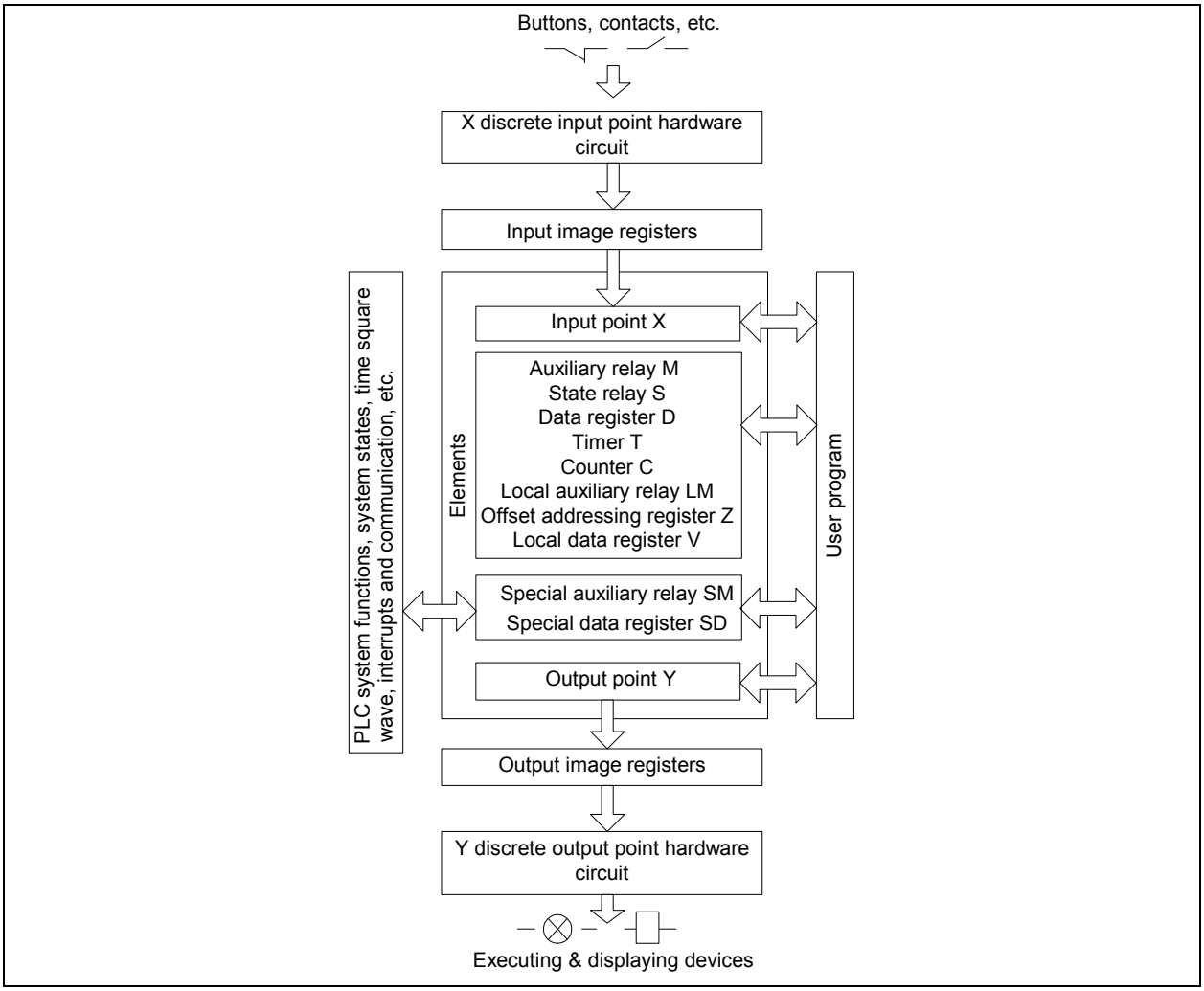


Figure 3-1 Types and functions of PLC elements

In this manual, the elements are named according to their types. For example:

- Input point X, or “X element” for short
- Output point Y, or “Y element” for short
- Auxiliary relay M, or “M element” for short
- Data register D, or “D element” for short
- State relay S, or “S element” for short

3.1.2 Element List

The elements of IVC series PLC are classified according to their functions, and are easily accessible.

The elements are listed in the following table.

Table 3-1 IVC series PLC elements

		IVC1 series	IVC2 series	Numbered in
Element resources Note 4	I/O	128I/128O (Input: X0 ~ X177. Output: Y0 ~ Y177) Note 1	256I/256O (Input: X0 ~ X377. Output: Y0 ~ Y377) Note 1	Octal
	Auxiliary relay	2048 (M0 ~ M2047)	2000 (M0 ~ M1999)	Decimal
	Local auxiliary relay Note 5	64 (LM0 ~ LM63)	64 (LM0 ~ LM63)	Decimal
	Special auxiliary relay	256 (SM0 ~ SM255)	256 (SM0 ~ SM255)	Decimal
	State relay	1024 (S0 ~ S1023)	992 (S0 ~ S991)	Decimal
	Timer	256 (T0 ~ T255) Note2	256 (T0 ~ T255) Note 2	Decimal
	Counter	256 (C0 ~ C255) Note 3	256 (C0 ~ C255) Note 3	Decimal
	Data register	8000 (D0 ~ D7999)	8000 (D0 ~ D7999)	Decimal
	Local data register Note 5	64 (V0 ~ V63)	64 (V0 ~ V63)	Decimal
	Offset addressing register	16 (Z0 ~ Z15)	16 (Z0 ~ Z15)	Decimal
	Special data register	256 个 (SD0 ~ SD255)	256 个 (SD0 ~ SD255)	Decimal

Notes:

1: The X and Y elements are addressed in octal system, and X10 represents the 8th input point. The I/O point number here is the system capacity, while the actual system I/O point number is determined by the actual system configuration (including extension modules and power supply).

2: The T elements are addressed according to the timing precision:

- 100ms: T0 ~ T209
- 10ms: T210 ~ T251
- 1ms: T252 ~ T255

3: The C elements are addressed according to the counter types and functions:

- 16bit up counter: C0 ~ C199
- 32bit bi-directional counter: C200 ~ C235
- 32bit high speed counter: C236 ~ C255

4: Part of PLC elements are reserved for internal tasks. Avoid using those elements in the user program. See *Appendix 3 Reserved Elements* .

5: These two elements are local variants that cannot be defined in the global variant table. When the user program calls subprograms or returns to the main program, they will be cleared, or be set through interface parameter transfer

3.1.3 Input And Output Points

Element mnemonic

- X (discrete input point)
- Y (discrete output point)

Function

The X and Y elements represent respectively the input state of hardware X terminal and output state of hardware Y terminal.

The state of X elements is obtained through the input image register, while the state of Y elements is output through the output circuit driven by the output image register. The two operations are carried out in the I/O Update stage of PLC scan cycle, as shown in Figure 3-2. For details, see *2.1.2 System Running Mechanism (Scan Cycle Model)* It is obvious that there is a brief delay in PLC's response to the I/O. The delay is related to the input filter, communication, internal tasks and scan cycle.

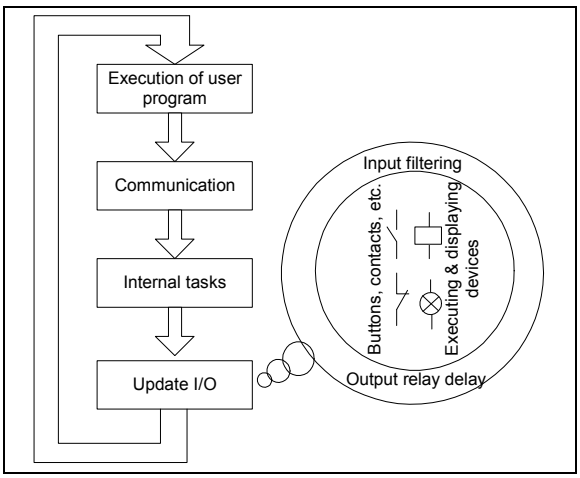


Figure 3-2 Schematic diagram of I/O update

Classification

X0 ~ X17 have digital filters whose filtering time can be set at the system block. Others use hardware filter. X0 ~ X5 can be used as the counting input point for high speed counters. Besides, X0 ~ X7 can also be used for inputting external interrupts, pulse tracking and SPD frequency detecting instruction.

Y0 and Y1 can be used for high speed output. Others are ordinary output points.

Elements numbered in

Octal, starting with 0. The X and Y elements of both the basic module and the I/O modules are numbered continuously like 0 ~ 7, 10 ~ 17, 20 ~ 27, and so on.

Data type

Boolean (both X and Y)

Available forms

NO and NC contacts (dependent on which instruction uses it)

The NO and NC contacts have opposite state values. They are sometimes referred to as "a" contact and "b" contact.

You can use NO and NC contacts of the Y element during programming.

Value assignment

1. The X elements accepts only hardware input state value and forced operation state value. In the user program, they cannot be changed through output or instructions, nor be set during system debugging.
2. You can assign values to Y elements with the OUT instruction, or set the state value of Y elements, or even force or write Y element values during system debugging.
3. Through the system block, you can set the output states of Y elements in the STOP state.

3.1.4 Auxiliary Relays

Element mnemonic

M

Function

The M state elements of discrete type are similar to the transfer relays in the actual electrical control circuits. You can use them to save various transit states in the user program.

Elements numbered in

Decimal, starting with 0.

Data type

Boolean

Available forms

NO and NC contacts.

Value assignment

1. Through instructions. 2. Write or force during system debugging.

Battery backed features

State	M elements in the saving range	M elements outside the saving range
Power loss	Remain unchanged	Cleared
RUN → STOP	Remain unchanged	Remain unchanged
STOP → RUN	Remain unchanged	Cleared
Note: The saving range is set through the system block. See *2.2.1 System Block*.		

Note

When using the N:N bus protocol, some M elements will be used by the system.

3.1.5 State Relays

Elemenet mnemonic

S

Alias

Step flag

Function

As the step flag, the S elements are used in the Sequential Function Chart (SFC). See *Chapter 7 SFC* Tutor.

Classification

S0 ~ S19: initial step flag

Others: normal step flag

Elements numbered in

Decimal, starting with 0

Data type

Boolean

Available forms

1. Representation of steps (when used in STL instruction)

2. NO and NC contacts (when not used in STL instruction). Similar to M elements, the NO and NC contacts of S elements are available during programming.

Value assignment

1. Through instructions. 2. Write or force during system debugging.

Battery backed features

State	S elements in the saving range	S elements outside the saving range
Power loss	Remain unchanged	Cleared
RUN → STOP	Remain unchanged	Remain unchanged
STOP → RUN	Remain unchanged	Cleared
Note: The saving range is set through the system block. See *2.2.1 System Block*		

3.1.6 Timer

Element mnemonic

T

Function

The T element contains a word element (2 bytes) and a bit element. The T word element can record a 16-bit value. The T bit element represents the timer coil state and is applicable to logic control.

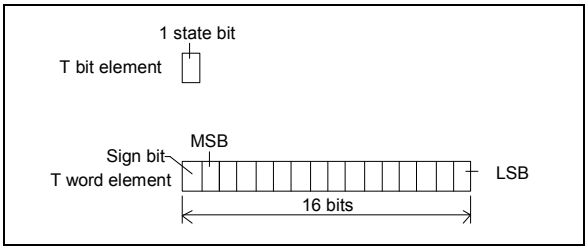


Figure 3-3 T element

Classification

According to the timing precision, the T elements are classified into three types:

T element	Timing precision
T0 ~ T209	100ms
T210 ~ T251	10ms
T252 ~ T255	1ms

The T elements with the timing precision of 1ms are activated by interrupts, unrelated to the PLC scan cycle. Their action time is the most precise. The update and action time of other T elements are related to PLC scan cycles.

Elements numbered in

Decimal, starting with 0

Data type

Boolean, word

Available forms

The timing and action mode of T elements are determined by the timing instruction that uses them. There are four timing instructions: TON, TOF, TONR and TMON. See *Chapter 5 Basic Instructions* for details.

Value assignment

1. Through instructions. 2. Write or force during system debugging.

Battery backed features

State	T elements in the saving range (for IVC2 only)	T elements outside the saving range
Power loss	Remain unchanged	Cleared
RUN → STOP	Remain unchanged	Remain unchanged
STOP → RUN	Remain unchanged	Cleared
Note: The saving range is set through the system block. See *2.2.1 System Block*		

Note

The maximum timing value of T element is 32767. The preset value is -32768 ~ 32767. Because T elements act only when the counted value reaches or exceeds the preset value, it is pointless setting the preset value as a negative number.

3.1.7 Counter

Element mnemonic

C

Function

The C element contains a bit element and a word (or a double word) element. The word elements can record 16-bit or 32-bit counted numbers, and is used as a value in the program. The bit element represents the state of the counter coil and is applied to logic control.

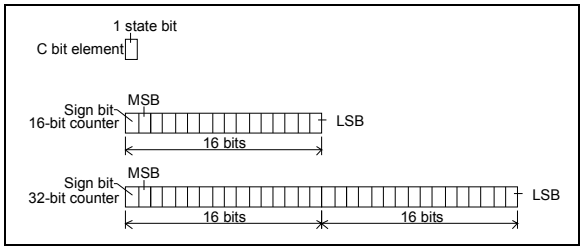


Figure 3-4 C element

Classification

Two types: 16-bit counter and 32-bit counter

Elements numbered in

Decimal, starting with 0

Data type

Boolean, word or double word.

Available forms

The instructions that may use the C elements are classified into 4 types: CTU, CTR, DCNT and the high speed counter instructions. See *Chapter 5 Basic Instructions* and *Chapter 6 Application Instructions* for details.

The classification of C elements is shown below:

C elements	Type	Applicable to
C0 ~ C199	16-bit up counter	CTU, CTR
C200 ~ C235	32-bit bi-directional counter	DCNT
C236 ~ C255	32-bit high speed counter	High speed I/O instructions

Value assignment

1. Through instructions. 2. Write or force during system debugging.

Battery backed features

State	C elements in the saving range	C elements outside the saving range
Power loss	Remain unchanged	Cleared
RUN → STOP	Remain unchanged	Remain unchanged
STOP → RUN	Remain unchanged	Cleared
Note: The saving range is set through the system block. See *2.2.1 System Block*		

3.1.8 Data Register

Element mnemonic

D

Function

As a data element, the D elements are used in many calculation and control instructions as the operands.

Elements numbered in

Decimal, starting with 0

Data type

Every D element is a 16-bit register that can store data, like an 16-bit integer.

Two D elements can form a double word and store a 32-bit data, such as the long integer data or floating-point data.

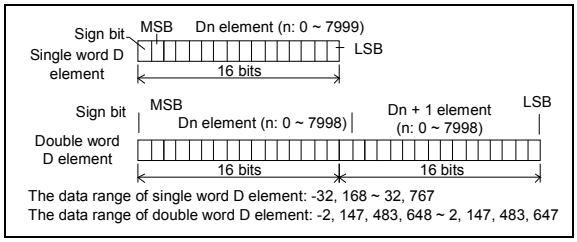

Sign bit
Single word D element
MSB
Dn element (n: 0 ~ 7999)
LSB
16 bits
Sign bit
Double word D element
MSB
Dn element (n: 0 ~ 7998)
Dn + 1 element (n: 0 ~ 7998)
LSB
16 bits
16 bits
The data range of single word D element: -32, 168 ~ 32, 767
The data range of double word D element: -2, 147, 483, 648 ~ 2, 147, 483, 647

Figure 3-5 D element

Available forms

The D elements are used in many calculation and control instructions as the operands.

Value assignment

1. Through initialization. 2. Through instructions.
3. Write or force during system debugging.

Battery backed features

State	D elements in the saving range	D elements outside the saving range
Power loss	Remain unchanged	Cleared
RUN → STOP	Remain unchanged	Remain unchanged
STOP → RUN	Remain unchanged	Cleared
Note: The saving range is set through the system block. See *2.2.1 System Block*		

Note

In a double word D element, the higher 16-bit is in the first D element; and the lower 16-bit is in the second D element.

Note

Some D elements may be reserved for internal tasks when the FREQUENCY CONVERTER instructions or N:N bus protocol is used.

3.1.9 Special Auxiliary Relay

Element mnemonic

SM

Function

The SM elements are closely related to the PLC system function. They reflect PLC system function and system state. For details, see *Appendix 1 Special* Auxiliary Relay.

Classification

The frequently used SM elements include:

- SM0: PLC operation monitor bit. It is ON when the PLC is in RUN state.
- SM1: initial operation pulse bit. It is ON in the first scan cycle of PLC operation.
- SM3: system error. It is ON if any system error is detected after PLC is powered on or when PLC changes from STOP to RUN.
- SM10 ~ SM12: respetively the clock square-wave cycled at 10ms, 100ms and 1s (flipping-over twice in a cycle).

In addition, you can use, control or change the PLC system function by adjusting certain SM elements. Such elements include:

SM40 ~ SM68: interrupt control flag bit. Setting these SM elements will enable the corresponding interrupts.

SM80/81: Y0/Y1 high speed pulse output stop instruction.

SM110 ~ SM114: monitor bit of free port 0

SM135/136: Modbus communication flag bit.

SM172 ~ SM178: integrated analog channel enabling flag (valid only for IVC1-1614MAR1)

Elements numbered in

Decimal, starting with 0

Data type

Boolean

Available forms

NO and NC contacts

Value assignment

1. Through instructions. 2. Write or force during system debugging.

3.1.10 Special Data Register

Element mnemonic

SD

Function

The SD elements are closely related to the PLC system function. They reflect PLC system function parameters, state code and instruction execution data. See *Appendix 2 Special* Data Register for details.

Classification

- The frequently used SD elements include:
- SD3: system error code.
- SD50 ~ SD57: high speed pulse output monitor.
- SD100 ~ SD106: real time clock data.

In addition, you can change PLC system function parameters by changing certain SD elements. Such elements include:

SD66 ~ SD68: cycle of timed interrupt.

SD80 ~ SD89: locating instruction parameters.

SD100 ~ SD106: real time clock data.

Elements numbered in

Decimal, starting with 0

Data type

Word (integer)

Available forms

Storage and calculation of integers

Value assignment

1. Through instructions. 2. Write or force during system debugging.

🕮 **Note**

You cannot assign values to the read only SD elements.

3.1.11 Offset Addressing Register

Element mnemonic

Z

Function

The Z elements are 16-bit registers that can store signed integers. For detailed offset addressing information, see *3.2.2 Z Addressing* Mode (Offset Addressing Mode).

Elements numbered in

Decimal, starting with 0

Data type

Word

Available forms

The Z elements are used for offset addressing. You need to write the addressing offset to the Z elements before you can use them.

Value assignment

1. Through instructions. 2, Write or force during system debugging.

3.1.12 Local Auxiliary Relay

Element mnemonic

LM

Function

The LM elements are local variants and can be used in the main program and subprograms. But being local variants, they are valid only in a certain program. Different programs cannot share the same LM element directly. When the system jumps from one program to another, the system will redefine the LM element. When the system returns to the main program or calls a subprogram, the redefined LM element will be cleared, or be set by the interface parameter transfer.

The LM elements can be used to define the interface parameters of subprograms to realize interface parameter transfer. For details, see *4.4 Subprogram*.

Elements numbered in

Decimal, starting with 0

Data type

Boolean

Available forms

NO and NC contact

Value assignment

1. Through instructions. 2. Write or force during system debugging.

3.1.13 Local Data Register

Element mnemonic

V

Function

The V elements are local variants and can be used in the main program and subprograms. But being local variants, they are valid only in a certain program. Different programs cannot share the same V element directly. When the system jumps from one program to another, the system will redefine the V element. When the system returns to the main program or calls a subprogram, the redefined V element will be cleared, or be set by the interface parameter transfer.

The V elements can be used to define the interface parameters of subprograms to realize interface parameter transfer. For details, see *4.4 Subprogram*.

Elements numbered in

Decimal, starting with 0

Data type

Boolean

Available forms

Word, for numeric information

Value assignment

1. Through instructions. 2. Write or force during system debugging

3.2 Elements Addressing Mode

3.2.1 Kn Addressing Mode (Combined Bit-string Addressing Mode)

Concept

The Kn addressing mode, or combined bit-string addressing mode, realizes addressing by combining bit elements into words or double words.

Kn addressing method

The format is: “K (n) (U)”, where the “n” is an integer from one to eight, standing for the length of the bit string: n × 4. The “U” stands for the address of the starting element.

For example:

1. K1X0 stands for a word made up of (X0, X1, X2, X3).
2. K3Y0 stands for a word made up of (Y0, Y01, Y02, Y03), (Y04, Y05, Y06, Y07), (Y10, Y11, Y12, Y13).
3. K4M0 stands for a word made up of M0, M1, M2, M3…, M15.
4. K8M0 stands for a word made up of M0, M1, M2, M3…, M31.

Data storage using Kn addressing mode

The following is an example of how a specific data can be stored using the Kn addressing mode:

MOV 2#10001001 K2M0 (which is equal to MOV 16#89 K2M0, or MOV 137 K2M0). After executing the instruction, the result is:

	Highest bit							Lowest bit
K2M0	M7	M6	M5	M4	M3	M2	M1	M0
16#89	1	0	0	0	1	0	0	1

Points to note

If the destination operand uses the Kn addressing mode, while the data to be stored is longer than the length of the destination operand, the system will keep the lower bits and discard the higher bits.

For example:

Execute instruction DBITS 16# FFFFFFF0 K1M0. After executing the instruction, the operand 2 (K1M0) should store the calculation result 16# 1c (28). However, the K1M0 is only 4 bits wide, which is not enough for 16# 1c. By discarding the higher bits, the actual operand 2 is K1M0 = 16# c (12).

3.2.2 Z Addressing Mode (Offset Addressing Mode)

Concept

The IVC2 series PLC provides the Z addressing mode, or offset addressing mode. You can use the Z elements (offset addressing register) to get indirect access to the targe elements.

Z addressing method

Targe address = Basic element address + Address offset stored in Z element

For example:

In the offset addressing mode, for D0Z0 (Z0 = 3), the target address is D3, because D0 is the basic address, and the offset address is stored in element Z0, which in this case, is 3.

Therefore when Z0 = 3, the instruction “MOV 45 D0Z0” is equal to “MOV 45 D3” in effect, because in both cases the D3 is set as 45 by the instruction.

Offset addressing example

1. Bit element offset addressing example

LD M01

MOV 6 Z1

SFTR X0Z1 M0 8 2

The preceeding instructions are in effect equal to:

LD M0 1

SFTR X6 M0 8 2

The addressing process is as follows:

Z1=6

X0Z1 = X (0+Z1) = X6

2. Word element offset addressing example

LD M0 1

MOV 30 Z20

MOV D100Z20 D0

The preceeding instructions are in effect equal to:

LD M0 1

MOV D130 D0

The addressing process is as follows:

Z20=30

D100 Z20 = D (100+Z20) = D130

Points to note

1. The Z elements store the offset for the offset addressing. They support signed integers, which means minus offset is supported.

For example:

MOV -30 Z20

MOV D100Z20 D0

The preceeding instructions are equal to the following one in effect:

MOV D70 D0

2. The SM elements and SD elements do not support the Z addressing mode.

3. Pay attention to the address range when using the Z addressing mode. For example, D7999Z0 (Z0 = 9) is outside the address range of the D elements, which is not bigger than D7999.

3.2.3 Kn Addressing In Combination With Z Addressing

The Kn addressing mode can be used in combination with the Z addressing mode. For example: K1X0Z10.

In this mode, the starting element address is found throught the Z addressing mode, then the Kn addressing mode is used to determine the length of the bit string.

For example:

LD M1

MOV 3 Z10

MOV K1X0Z10 D0

The preceeding instructions are in effect equal to:

LD M1

MOV K1X3 D0

The addressing process is as follows:

Z10 = 3

K1X0Z10=K1X (0+Z10) = K1X3

3.2.4 Storing & Addressing 32-Bit Data In D & V Elements

Storing 32-bit data in D and V elements

The DINT, DWORD and REAL data are all 32-bit, while the D and V elements are both 16-bit. Two consecutive D or V elements are needed to store the 32-bit data.

The IVC2 series PLC stores the 32-bit data in the Big Endian mode, which means the elements with smaller addresses are used to store the higher bits, while the elements with bigger addresses are used to store the lower bits.

For example, the signless integer “16# FEA8_67DA” is stored in the element (D0, D1). The actual storing format is:

D0	0xFEA8
D1	0x 67DA

Addressing 32-bit data in D and V elements

You can use a D or V element to locate a 16-bit data, such as an INT or WORD data, or a 32-bit data, such as a DINT or DWORD data.

If a D or V element address is used in an instruction, the operand data type determines whethther the data is 16-bit or 32-bit.

For example:

In the instruction “MOV 16#34 D0”, the address D0 stands for a single D0 element, because operand 2 of the MOV instruction is of the WORD data type.

In the instruction “DMOV 16# FEA867DA D0”, the address D0 stands for two consecutive words: D0 and D1, becase operand 2 of the DMOV instruction is of the DWORD data type.

3.3 Data

3.3.1 Data Type

All instruction operands are of a certain data type. There are altogether six data types, as listed in the following table:

Table 3-2 Operand data types

Data type	Type description	Data width	Range
BOOL	Bit	1	ON, OFF (1, 0)
INT	Signed integer	16	-32768 ~ 32767
DINT	Signed double integer	32	-2147483648 ~ 2147483647
WORD	Word	16	0 ~ 65535 (16#0 ~ 16#FFFF)
DWORD	Double word	32	0 ~ 4294967295 (16#0 ~ 16#FFFFFFFF)
REAL	Floating point	32	±1.175494E-38 ~ ±3.402823E+38

3.3.2 Correlation Between Elements And Data Types

The elements used as instruction operands must have suitable data types. The correlations are listed in the following table.

Table 3-3 Elements and data type correlations

Data type	Elements												
BOOL										C	T		
	X	Y	M	S	LM	SM							
INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z
DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V	
WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z
DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	
REAL	Constant							D				V	

If an instruction uses an operand with unsuitable data type, the instruction will be deemed illegal. For example, instruction “MOV 10 X0” is illegal because operand 2 of the MOV instruction is of signed integer data type, while the X0 element can store only Boolean data.

Note

1. When the operand is of INT or WORD type, the applicable elements include KnX, KnY, KnM, KnS, KnLM and KnSM, where $1 \le n \le 4$
2. When the operand is of DINT or DWORD type, the applicable elements include KnX, KnY, KnM, KnS, KnLM and KnSM, where $5 \le n \le 8$
3. When the operand is of INT or WORD type, the applicable C elements are C0 ~ C199.
4. When the operand is of DINT or DWORD type, the applicable C elements are C200 ~ C255.

3.3.3 Constant

You can use constants as the instruction operands. IVC2 series PLC supports input of multiple types of constants. The usual constant types are listed in the following table:

Table 3-4 Constant types

Constant type	Example	Valid range	Remarks
Decimal constant (16-bit signed integer)	-8949	-32768 ~ 32767	
Decimal constant (16-bit unsigned integer)	65326	0 ~ 65535	
Decimal constant (32-bit signed integer)	-2147483646	-2147483648 ~ 2147483647	
Decimal constant(32-bit unsigned integer)	4294967295	0 ~ 4294967295	
Hex constant (16-bit)	16#1FE9	16#0 ~ 16#FFFF	The hex, octal or binary constants are neither positive nor negative by themselves. When used as operands, the positive and negative nature of these constants are determined by the data type of the operand.
Hex constant (32-bit)	16#FD1EAFE9	16#0 ~ 16#FFFFFFFF	
Octal constant (16-bit)	8#7173	8#0 ~ 8#177777	
Octal constant (32-bit)	8#71732	8#0 ~ 8#37777777777	
Binary constant (16-bit)	2#10111001	2#0 ~ 2#1111111111111111	
Binary constant (32-bit)	2#10111001111 11	2#0 ~ 2#1111111111111111 1111111111111111	
Single-precision floating point	-3.1415E-16 3.1415E+3 0.016	±1.175494E-38 ~ ±3.402823E+38	Compliant with IEEE-754. The programming software can display and input floating point constants with 7-bit of operational accuracy

Chapter 4 Programming Concepts

This chapter details the programming of IVC series small PLC, including the programming language, program components, data type, addressing mode and annotating function. The programming and usage of subprograms are also introduced, and finally, the general explanation of instructions.

4.1 Programming Language....45
4.1.1 LAD....45
4.1.2 IL....46
4.1.3 SFC....46
4.2 Program Components....47
4.2.1 User Program....47
4.2.2 System Block....47
4.2.3 Data Block....47
4.3 Block Comment And Variable Comment....47
4.3.1 Block Comment....47
4.3.2 Variable Comment....48
4.4 Subprogram....50
4.4.1 Concept....50
4.4.2 Points To Note For Using SBRs....50
4.4.3 SBR Local Variable Table....50
4.4.4 SBR Parameter Transfer....51
4.4.5 Example....51
4.5 General Information Of Instructions....52
4.5.1 Instruction Operands....52
4.5.2 Flag Bit....52
4.5.3 Limits To Instruction Usage....53

4.1 Programming Language

Three programming languages are provided: ladder diagram (LAD), instruction list (IL) and Sequential Function Chart (SFC).

4.1.1 LAD

Concepts

The LAD is a widely-used diagram programming-language, similar to the electric (relay) control diagram. It features:

1. Left bus, with right bus omitted.

2. All control output elements (coils) and functional blocks (application instructions) share the same power flow inlet.

The electric control diagram and LAD are equivalent to a certain degree, as shown in the following figure.

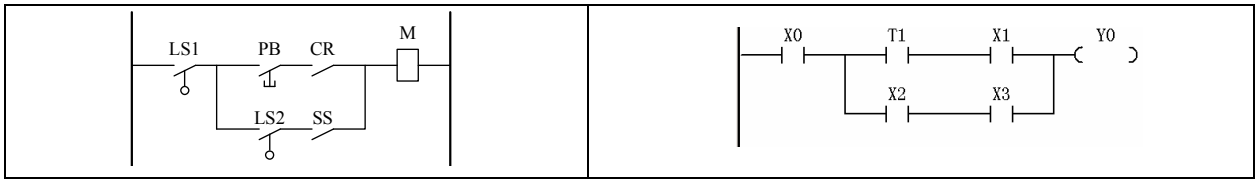


Figure 4-1 The equivalence between electric control diagram and LAD

LAD basic programming components

According to the principles in electric control diagram, several basic programming components are abstracted for the LAD:

1. Left bus: Corresponding to the control bus in electric control diagram, it provides power for the control circuit.

2. Connecting line (— |): Corresponding to the electric connection in electric control diagram, it connects different components.

3. Contact (⊣⊢): Corresponding to the input contact in electric diagram, it controls the ON/OFF and direction of control currents. The parallel and serial connection of contacts stands for the logic calculation of inputs, determining the transfer of power flow.

4. Coil (⊸○): It corresponds to the relay output in electric control diagram.

5. Function block (□): Or application instruction. Corresponding to the execution unit or functional device that provides special functions in electric control diagram, it can accomplish specific control function or control calculation function (like data transmission, data calculation, timer and counter).

Power flow

Being an important concept in LAD, the power flow is used to drive coils and application instructions, which is similar to the control current output by the driving coil, and executed by the execution unit in electric control diagram.

In LAD, the coils or application instructions must be preceded with power flow, because the coils can output and instructions can be executed only when the power flow is ON.

The following figure demonstrates the power flow in LAD and the how the power flow drives coils or function blocks.

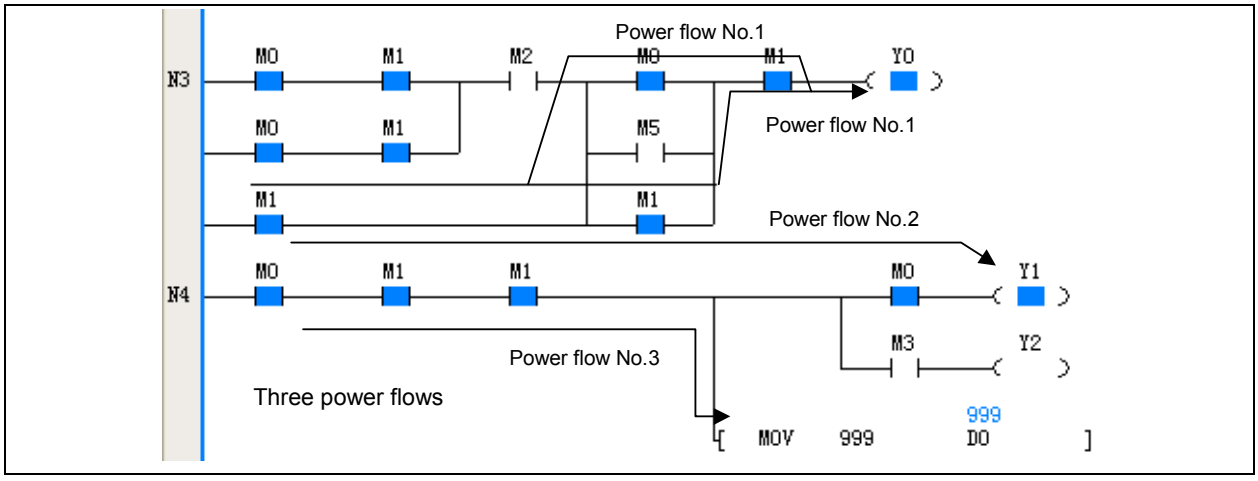


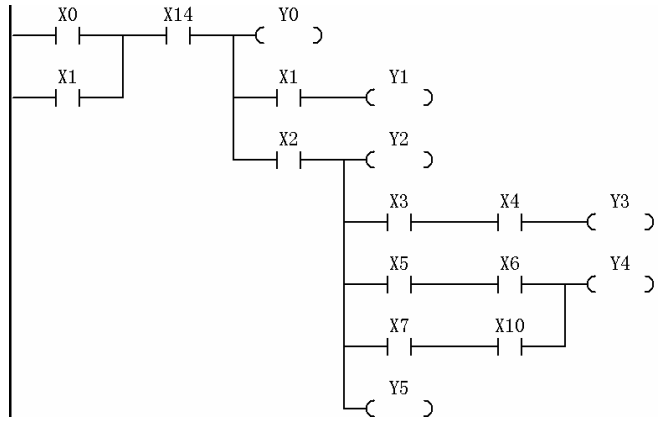
Figure 4-2 Power flow and its driving function

4.1.2 IL

The IL, or the instruction list composed by users, is a text programming language.

The user program stored in the PLC basic module is actually the instruction list recognizable to the basic module. The system realizes the control function by executing the instructions in the list one by one.

The following is an example of equivalent LAD and IL.

LAD	IL
	LD X0 OR X1 AND X14 MPS OUT Y0 AND X1 OUT Y1 MPP AND X2 MPS OUT Y2 AND X3 AND X4 OUT Y3 MRD LD X5 AND X6 LD X7 AND X10 ORB ANB OUT Y4 MPP OUT Y5

4.1.3 SFC

The SFC is a diagram programming-language usually used to realize sequence control, which is a control process that can be divided into multiple procedures and proceed according to certain working sequence.

The user program designed with SFC is direct and clear because it has a structure similar to the actual sequence control process.

See the following figure for a simple example of SFC.

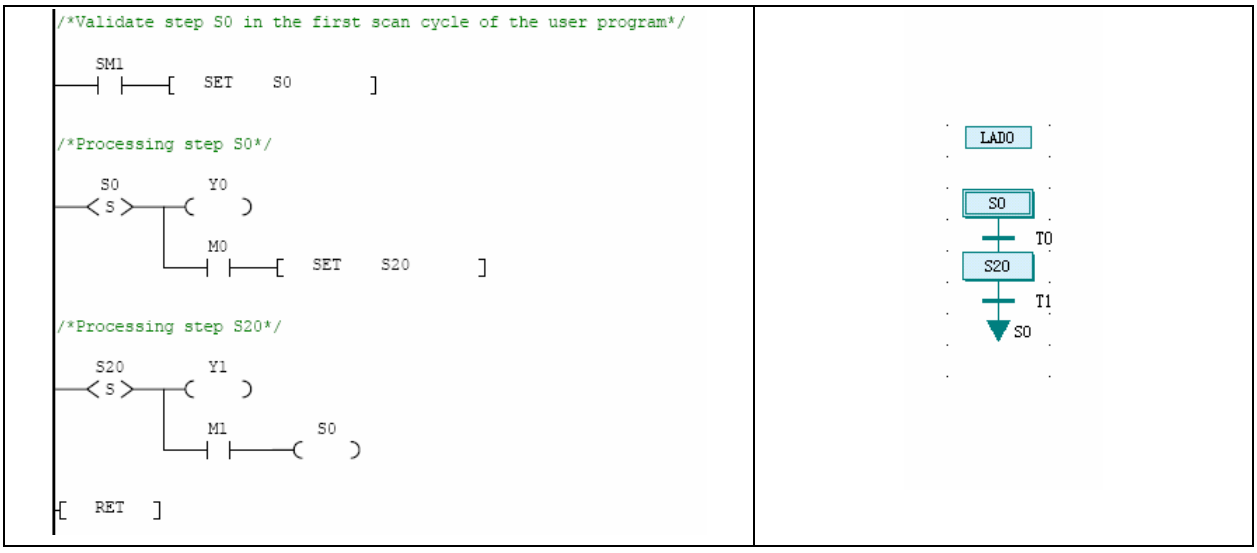


Figure 4-3 Example of SFC

4.2 Program Components

The program components include user program, system block and data block. You can change these components by programming.

4.2.1 User Program

A user program is the program code composed by users. It must be compiled into executable instruction list, downloaded to the PLC and executed to realize the control function.

The user program comprises three Program Organization Units (POU): main program (MAIN), subprogram (SBR) and interrupt (INT).

Main program

The main program is the main body and framework of the user program. When the system is in RUN state, the main program will be executed cyclically.

One user program has only one main program.

Subprogram

A subprogram is a program independent in structure and function. It can be called by other POUs. Subprograms generally have call operand interface and are executed only when being called.

A user program can have random number of subprograms, or no subprogram at all.

Interrupt

An interrupt is a program section handling a specific interrupt event. A specific interrupt event always corresponds to a specific interrupt.

Upon the occurance of an interrupt event, a ordinary scan cycle will be interrupted. The system will run the corresponding interrupt until the interrupt is finished, when the system will return to the ordinary scan cycle.

A user program can have random number of interrupts, or no interrupts at all.

4.2.2 System Block

The system block contains multiple system configuration parameters. You can modify, compile and download the system block to configure the operation mode of the basic module.

For details, see *2.2.1 System Block* or the related description in *AutoStation Programming Software User Manual*.

4.2.3 Data Block

The data block contains the values of D elements. By downloading the data block to the PLC, you can set a batch of designated D elements.

If the **Datablock enabled** is checked in the **Advanced Settings** tab of **System block,** the D elements will be initialized by the data block before the PLC executes the user program.

4.3 Block Comment And Variable Comment

4.3.1 Block Comment

You can add comments to the program. Occupying a whole row, each piece of comment can be used to explain the function of the following program block.

In the program, right click and select **Insert Row** to insert a row above the current row. You can use a empty row to separate two program sections.

To make a block comment, just select an empty row, right click and select **Insert Block Comment.**

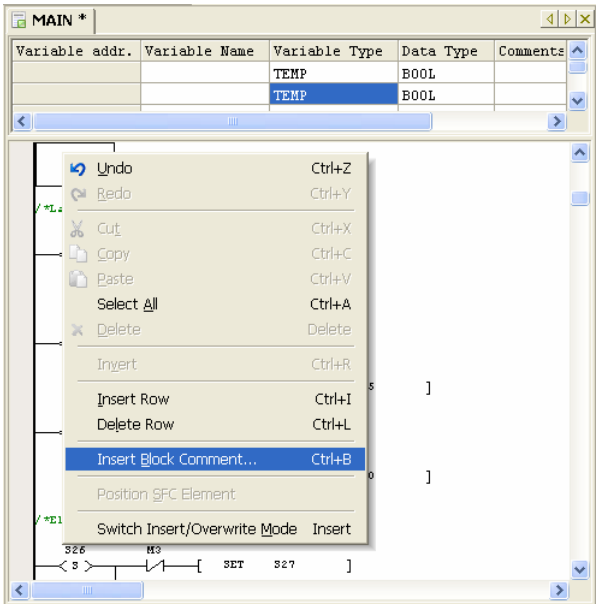


Figure 4-4 Adding block comment

Input your comment into the **Block Comment** dialogue box that pops out and click the **OK** button

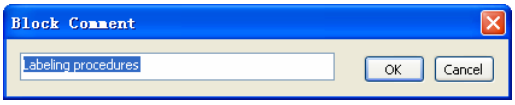


Figure 4-5 Block comment dialogue box

The comment will appear in the empty row, as shown below:

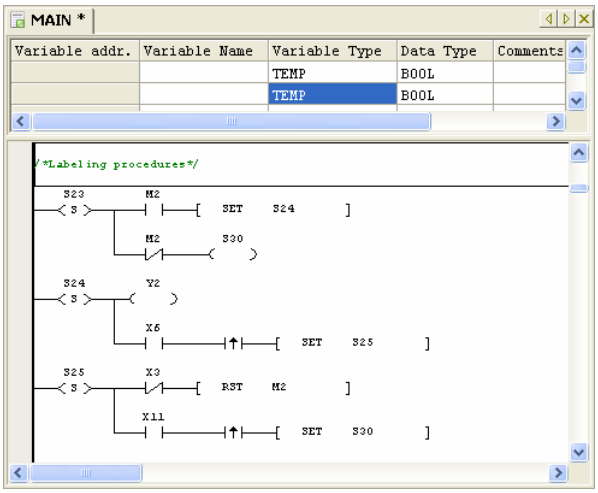


Figure 4-6 The block comment

A block comment occupies a whole row. You cannot add a block comment to an occupied row, nor can a row occupied by a comment be used for other purposes.

4.3.2 Variable Comment

You can define variables in the **Local variable table** and **Global variable table**. (See *2.2.3 Global Variable Table* and *4.4.3 SBR Local Variable Table*) , and use them in the LAD programming language. A variable can stand for a certain address to make the program more sensible. Figure 4-7 shows some variables defined in a global variable table.

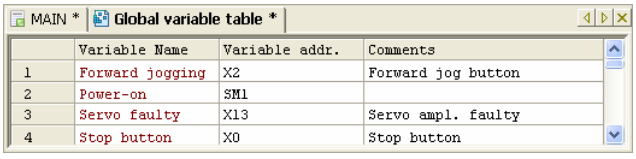


Figure 4-7 Variables defined in the global variable table

Symbol Addressing

When the defined variables are used, you can select **View -> Symbole Addressing** to display their names instead of their addresses in the LAD or IL program.

The following figure shows the LAD program when the **Symbol Addressing** is not checked.

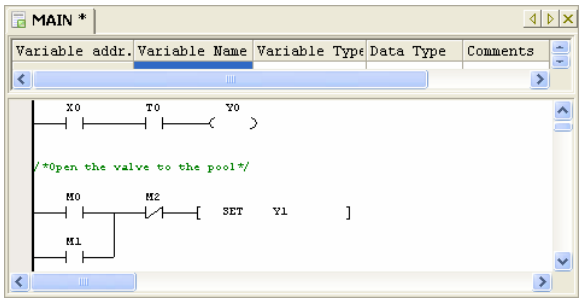


Figure 4-8 When symbole addressing is unchecked

The following figure shows the LAD program when the **Symbol Addressing** is checked.

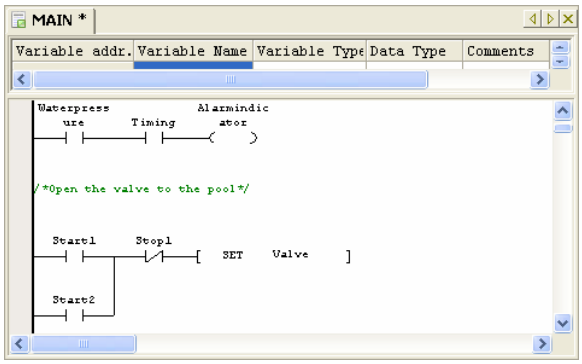


Figure 4-9 When symbole addressing is checked

Element comment

You can select **View -> Element Comment** to display the element comments in the LAD program, as shown in Figure 4-10.

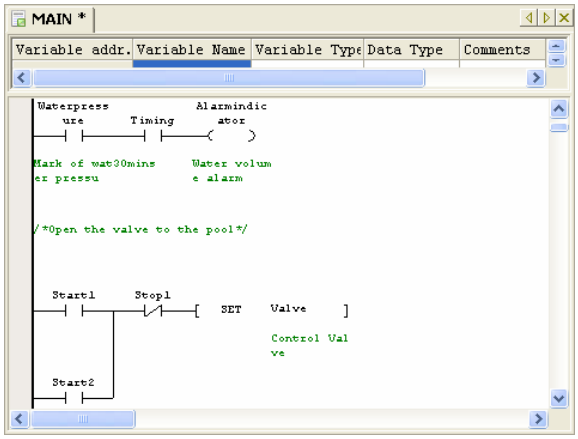


Figure 4-10 The LAD program displaying element comments

Note

The block comment, global variable table and local variable table can be compiled and downloaded to the IVC2 series PLC. To store such information, battery backup is needed. However, although battery failure may cause information loss, comment upload failure and user information file error report, the user program can still run normally.

4.4 Subprogram

4.4.1 Concept

Being an optional part of the user program, a subprogram (SBR) is an independent Program Organization Unit (POU) that can be called by the main program or other SBRs.

You can use SBRs in your user program to:

1. Reduce the size of the user program. You can write a repeated program section as a SBR and call it whenever necessary.
2. Clarify the program structure, particularly the structure of the main program.
3. Make the user program more transplantable.

4.4.2 Points To Note For Using SBRs

Note the following when writing or calling a SBR:

1. The PLC supports up to 6 levels of SBR nesting.

The following is an fine example of 6-level of SBR nesting:

MAIN → SBR1 → SBR2 → SBR3 → SBR4 → SBR5 → SBR6 (where the "→" represents calling with the CALL instruction)

2. The PLC does not support recursive calling and cyclic calling of SBRs.

The following two examples show two illegal SBR callings.

- MAIN→SBR0→SBR0 (recursive calling, illegal)
- MAIN→SBR0→SBR1→SBR0 (cyclic calling, illegal)

3. You can define up to 64 SBRs in a user program.
4. You can define up to 16 bit variables and 16 word variables in the local variable table of a SBR.
5. When calling a SBR, the operand type of the CALL instruction must match the variable type defined in the SBR local variable table. The compiler will check the match.
6. The interrupts are not allowed to call SBRs.

4.4.3 SBR Local Variable Table

Concept

The SBR local variable table displays all SBR interface parameters and local variables (both are called variables) and stipulates their properties.

SBR variable properties

The SBR variables (including interface parameters and local variables) have the following properties:

1. Variable address

Based on the variable data type, the software will automatically assign a fixed LM or V element address to each SBR variable in sequence.

2. Variable name

You can give each SBR variable a name (alias). You can use a variable in the program by quoting its name.

3. Variable type

The SBR variables are classified into the following four types:

- IN: The IN type variables can transfer the inputs of SBR when the SBR is being called.
- OUT: The OUT type variables can transfer the SBR execution result to the main program when a SBR calling ends.
- IN_OUT: The IN type variables can transfer the inputs of SBR when the SBR is being called, or transfer the the SBR execution result to the main program when a SBR calling ends.
- TEMP: The TEMP variables are local variables that are valid only within the SBR.

4. Data type

The variable data type specifies the range of the data. The variable data types are listed in the following table.

Table 4-1 Variable data types

Data type	Description	Occupid LM/V element address
BOOL	Bit type	One LM element address
INT	Signed integer type	One V element address
DINT	Signed double integer type	Two consecutive V element addresses
WORD	Word type	One V element address
DWORD	Double word type	Two consecutive V element addresses
REAL	Floating point type	Two consecutive V element addresses

4.4.4 SBR Parameter Transfer

If local input or output variables are defined in a SBR, when the main program calls the SBR, you should input the corresponding variable values, global variables or temporary variables into the SBR interface parameters. Note that the global variable should be of the same data type with the local variable.

4.4.5 Example

What follows is an example of how to write and call a SBR.

Function of this example SBR

Call SBR_1 in the main program to complete a adding calculation of two integer constants 3 and 2, and assign the result 5 to D0.

Operation procedures

Step 1: Insert a SBR into the project and name it as SBR_1.

Step 2: Write SBR_1.

1. Set the SBR calling interface through the SBR_1 variable table.

1) Variable 1: Name it as IN1 (variable type: IN). Set the data type as INT. The software will assign it with a V element address of V0.

2) Variable 2: Name it as IN2 (variable type: IN). Set the data type as INT. The software will assign it with a V element address of V1.

3) Variable 3: Name it as OUT1 (variable type: OUT). Set the data type as INT. The software will assign it with a V element address of V2.

2. Write the SBR_1 as:

```
LD   SM0
ADD  #IN1  #IN2  #OUT1
```

The above program is shown in the following figure.

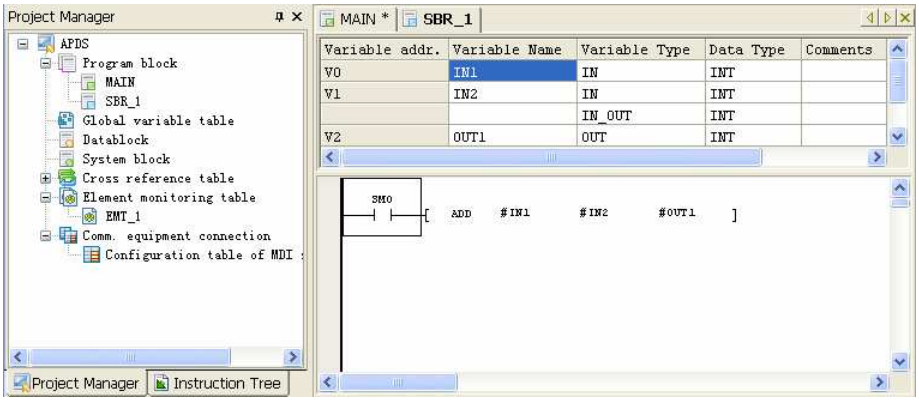


Figure 4-11 Writing SBR_1

Step 3: Write the main program and call the SBR

Use the CALL instruction in the main program to call SBR_1.

The corresponding main program is as shown below:

```
LD   M0
CALL  SBR_1  3  2  D0
```

You can use the parameter transfer relationship table as shown in the following figure to set the parameters transferred to the subprogram and specify the element for storing the result of the subprogram.

- Parameter IN1 is used to transfer constant integer 3
- Parameter IN2 is used to transfer constant integer 2
- The result OUT1 is stored in D0

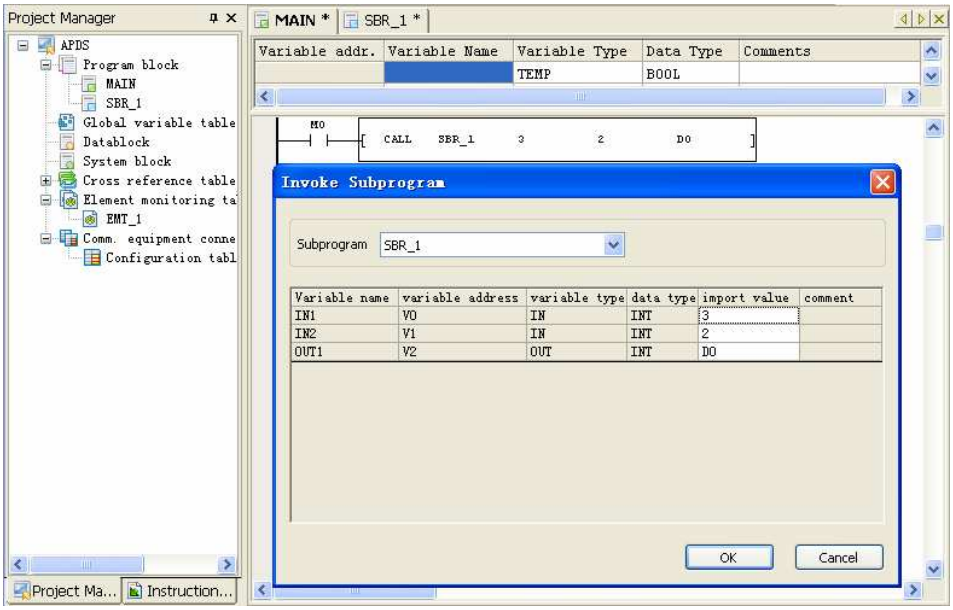


Figure 4-12 Calling subprogram

Step 4: Compile, download and run the user program and check the correctness of the SBR logic.

Execution result

When M0 is ON, SBR_1 will be called. Values 2 and 3 are transferred to the operands IN1 and IN2 to carry out the calculation operation. The result 5 is then returned to the main program, and in the end, D0 is 5.

4.5 General Information Of Instructions

4.5.1 Instruction Operands

The instruction operands can be classified into the following two types:

- Source operands: or S (or S_1, S_2, S_3 … when there are more than one of them in the same instruction). The instruction reads values from source operands for calculation.
- Destination operands: or D (or D_1, D_2, D_3 … when there are more than one of them in the same instruction). The instruction controls or outputs values to the destination operands.

The operands could be bit elements, word elements, double-word elements, or constants. See the specific instruction description in *Chapter 5* or *Chapter 6* for details.

4.5.2 Flag Bit

The instruction result may affect three kinds of flag.

Zero flag SM180

The zero flag is set when the instruction operation result is zero.

Carry flag SM181

The carry flag is set when the instruction operation result is a carry.

Borrow flag SM182

The borrow flag is set when the instruction operation result is a borrow.

4.5.3 Limits To Instruction Usage

There are some limits to the usage of certain instructions. For details, see the description of the specific instruction.

Exclusive hardware resources

Some instructions requires hardware resources. When a specific hardware is being used by a certain instruction, the access to the hardware will be denied to other instructions, because the occupation of the resource is exclusive.

Take the high speed I/O instructions and SPD instruction for example. Any of these instructions occupies a input point among X0 ~ X7. The limited resources will make it impossible to exeucte these instructions at the same time.

Exclusive time

The execution of certain instructions may take some time. During such period, the system will be too busy to execute other instructions.

Take the XMT instruction for example. Because of the time limit in communication, only one XMT instruction can be executed once. In the same way, the free port can execute only one RCV instruction once. Everytime when a Modbus instruction is being executed, the communication channel will be unavailable to other instructions for a while. The same is true to other instructions such as high speed output instruction, locating instructions and FREQUENCY CONVERTER instructions.

Application limit

Some instructions cannot be used in certain situations due to their limited application scope.

For example, instruction pair MC/MCR cannot be used in the steps of SFC.

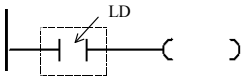
Chapter 5 Basic Instructions

This chapter details the basic instruction of IVC1 and IVC 20, including the instruction format (form), operand, influenced flag bit, function, example and sequence chart.

5.1 Contact Logic Instructions 55
5.1.1 LD: NO Contact Power-Flow Loading 55
5.1.2 LDI: NC Contact Power-Flow Loading 55
5.1.3 AND: NO Contact Power-Flow And 56
5.1.4 ANI: NC Contact Power-Flow And 56
5.1.5 OR: NO Contact Power-Flow Or 57
5.1.6 ORI: NC Contact Power-Flow Or 57
5.1.7 OUT: Power-Flow Output 58
5.1.8 ANB: Power-Flow Block And 58
5.1.9 ORB: Power-Flow Block Or 59
5.1.10 MPS: Output Power-Flow Input Stack 59
5.1.11 MRD: Read Output Power-Flow Stack Top Value 60
5.1.12 MPP: Output Power-Flow Stack Pop Off 60
5.1.13 EU: Power flow Rising Edge Detection 60
5.1.14 ED: Power flow Falling edge Detection 61
5.1.15 INV: Power-Flow Block Inverse 61
5.1.16 SET: Set 62
5.1.17 RST: Reset 62
5.1.18 NOP: No Operation 62
5.2 Main Control Instruction 62
5.2.1 MC: Main Contorl 62
5.2.2 MCR: Main Control Remove 63
5.3 SFC Instructions 64
5.3.1 STL: SFC State Load Instruction 64
5.3.2 SET Sxx: SFC State Shift 64
5.3.3 OUT Sxx: SFC State Jump 64
5.3.4 RST Sxx: SFC State Reset 65
5.3.5 RET: SFC Program End 65
5.4 Timer Instruction 65
5.4.1 TON: On-Delay Timing Instruction 65
5.4.2 TONR: On-Delay Remember Timing Instruction 66
5.4.3 TOF: Off-Delay Timing Instruction 66
5.4.4 TMON: Monostable Timing Instruction 67
5.5 Counter Instruction 67
5.5.1 CTU: 16-Bit Counter Counting Up Instruction 67
5.5.2 CTR: 16-Bit Counter Loop Cycle Counting Instruction 68
5.5.3 DCNT: 32-Bit Counting Instruction 69

5.1 Contact Logic Instructions

5.1.1 LD: NO Contact Power-Flow Loading

LAD: 		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: LD *(S)*		Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

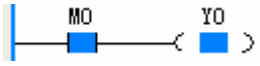
Operand description

S: Source operand

Function description

Connected to the left bus to connect (status: ON) or disconnect (status: OFF) the power flow.

Example



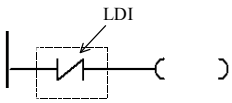

```
LD   M0
OUT  Y0
```

When M0 is ON, Y0 is ON.

Note:

For the contact logic instructions of IVC1 series, when the operands are M1536 ~ M2047, the actual program steps will be the instruction program steps plus 1.

5.1.2 LDI: NC Contact Power-Flow Loading

LAD: 		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: LDI *(S)*		Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

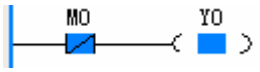
Operand description

S: Source operand

Function description

Connected to the left bus to connect (status: OFF) or disconnect (status: ON) the power flow.

Example



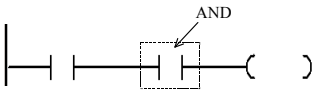

```
LDI  M0
OUT  Y0
```

When M0 is OFF, Y0 is ON.

Note:

For the contact logic instructions of IVC1 series, when the operands are M1536 ~ M2047, the actual program steps will be the instruction program steps plus 1.

5.1.3 AND: NO Contact Power-Flow And

LAD:															Applicable to	IVC2 IVC1
															Influenced flag bit	
IL: AND (S)															Program steps	1
Operand	Type	Applicable elements														Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T				

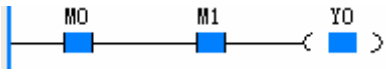
Operand description

S: Source operand

Function description

After conducting the “and” operation on the ON/OFF status of the designated contact (***S***) and the current power flow, assign the value to the current power flow.

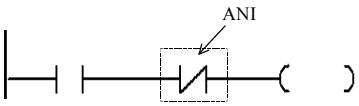
Example




```
LD   M0
AND  M1
OUT  Y0
```

When M0 is ON and M1 is ON, Y0 is ON.

5.1.4 ANI: NC Contact Power-Flow And

LAD:															Applicable to	IVC2 IVC1
															Influenced flag bit	
IL: ANI (S)															Program steps	1
Operand	Type	Applicable elements														Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T				

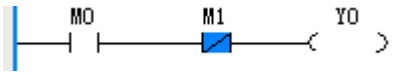
Operand description

S: Source operand

Function description

After reversing the ON/OFF status of the designated contact (***S***), conduct “and” operation on the reversed result and the current power flow, and then assign the value to the current power flow.

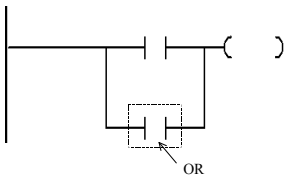
Example




```
LD   M0
ANI  M1
OUT  Y0
```

When M0 is ON and M1 is OFF, Y0 outputs ON.

5.1.5 OR: NO Contact Power-Flow Or

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: OR *(S)*	Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

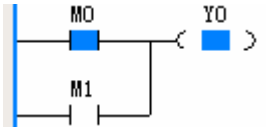
Operand description

S: Source operand

Function description

After conducting “OR” operation on the ON/OFF status of the designated contact (***S***) and the current power flow, assign the value to the current power flow.

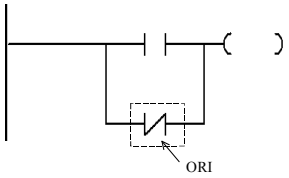
Example




```
LD   M0
OR   M1
OUT  Y0
```

When M0 or M1 is ON, Y0 is ON.

5.1.6 ORI: NC Contact Power-Flow Or

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ORI *(S)*	Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

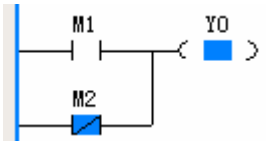
Operand description

S: Source operand

Function description

After reversing the ON/OFF status of the designated contact (S), conduct “OR” operation on the reversed result and the current power flow, and then assign the value to the current power flow.

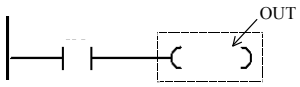
Example




```
LD   M0
ORI  M2
OUT  Y0
```

When M1 is ON or M2 is OFF, Y0 is ON.

5.1.7 OUT: Power-Flow Output

LAD:		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: OUT *(S)*		Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

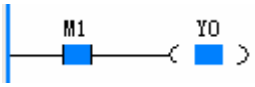
Operand description

S: Source operand

Function description

Assign the value of the current power flow to the designated coil (***D***)

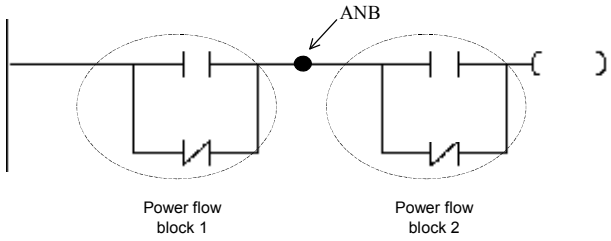
Example




```
LD   M1
OUT  Y0
```

When M1 is ON, Y0 is ON.

5.1.8 ANB: Power-Flow Block And

LAD:		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: ANB *(S)*		Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

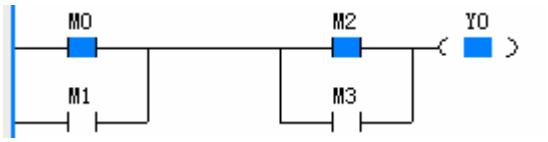
Operand description

S: Source operand

Function description

Conduct “and” operation on the power flow values of two power flow blocks, and then assign the value to the current power flow.

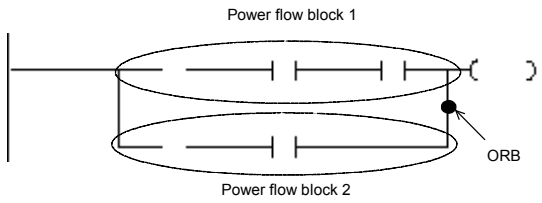
Example




```
LD   M0
OR   M1
LD   M2
OR   M3
ANB
OUT  Y0
```

When M0 or M1 is on, and M2 or M3 is ON, Y0 is ON.

5.1.9 ORB: Power-Flow Block Or

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ORB *(S)*	Program steps	1

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S	LM	SM				C	T			

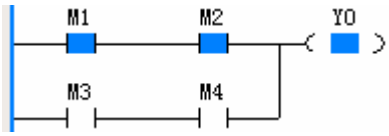
Operand description

S: Source operand

Function description

Conduct “or” operation on the power flow values of two power flow blocks, and then assign the value to the current power flow.

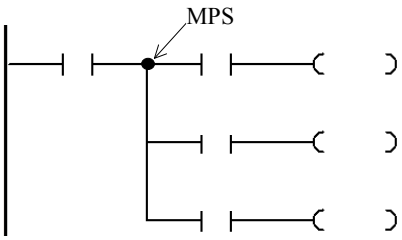
Example




```
LD   M1
AND  M2
LD   M3
AND  M4
ORB
OUT  Y0
```

When both M1 and M2 are ON, or both M3 and M4 are ON, Y0 outputs ON.

5.1.10 MPS: Output Power-Flow Input Stack

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: MPS	Program steps	1

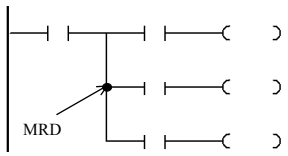
Function description

Push the current power flow value into the stack for storage, so that it can be used in the power flow calculation for the subsequent output branches.

Note:

It is prohibited to use the MPS instruction consecutively for over 8 times in a LAD program (with no MPP instruction in between), otherwise the power flow output stack may overflow.

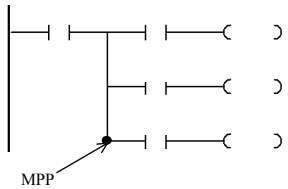
5.1.11 MRD: Read Output Power-Flow Stack Top Value

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: MRD	Program steps	1

Function description

Assign the top value of the power flow output stack to the current power flow.

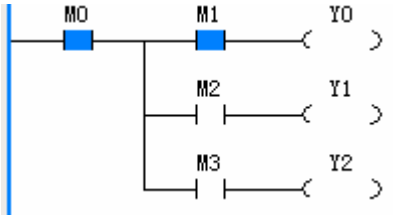
5.1.12 MPP: Output Power-Flow Stack Pop Off

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: MPP	Program steps	1

Function description

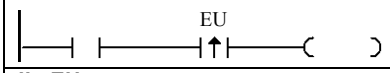
Pop the power flow output stack, and assign the popped value to the current power flow.

Example




```
LD    M0
MPS
AND   M1
OUT   Y0
MRD
AND   M2
OUT   Y1
MPP
AND   M3
OUT   Y2
```

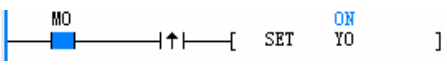
5.1.13 EU: Power flow Rising Edge Detection

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: EU	Program steps	2

Function description

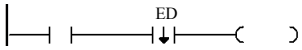
Compare the current power flow status with its previous status. If the power flow rises (OFF→ON), the output is valid in the current scan cycle.

Example




```
LD    M0
EU
SET   Y0
```

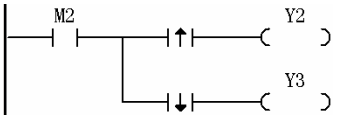
5.1.14 ED: Power flow Falling edge Detection

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ED	Program steps	2

Function description

Compare the current power flow status with its previous status. If the power flow falls (OFF→ON), the output is valid in the current scan cycle.

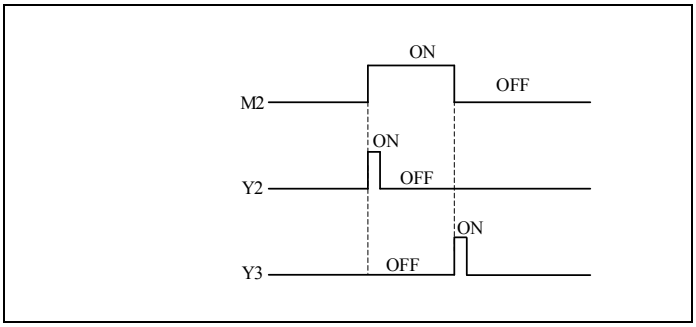
Example




```
LD   M2
MPS
EU
OUT Y2
MPP
ED
OUT Y3
```

1. In two consecutive scan cycles, the status of M2 contact is OFF and ON respectively. When the EU instruction detects a rising edge, Y2 will output ON status with the width of a scan cycle.
2. In two consecutive scan cycles, the status of M2 contact is ON and OFF respectively, when the ED instruction detects a trailing edge, Y3 will output ON status with the width of a scan cycle.

Sequence chart of example

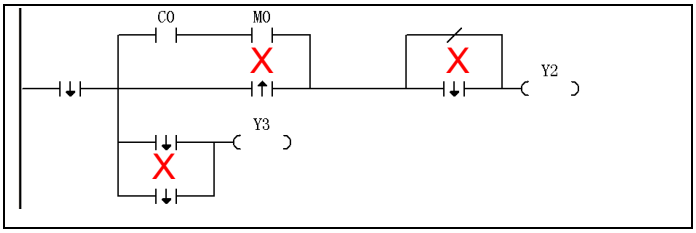


Note

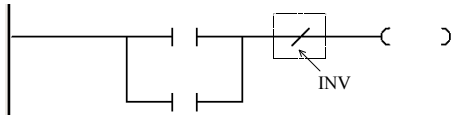
In LAD program, the rising edge contact or falling edge contact instruction shall be used in series rather than in parallel connection with other contact elements.

In LAD program, the rising edge contact and falling edge contact instruction cannot directly connect to the left power flow bus.

The examples of improper use of EU/ED instructions in LAD program are shown as follows:



5.1.15 INV: Power-Flow Block Inverse

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: INV	Program steps	1

Function description

Reverse the current power flow value and then assign to the current power flow.

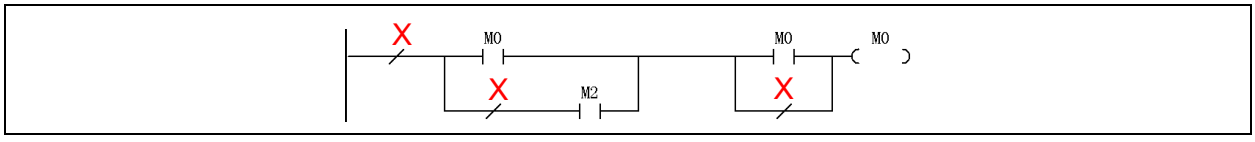
Note:

In LAD program, the INV instruction shall be used in series rather than in parallel connection with contacts.

INV cannot be used as the first instruction in the input parallel branch.

In LAD program, the INV instruction cannot directly connect to the left power flow bus.

The examples of improper use of INV instructions in LAD program are shown as follows:



5.1.16 SET: Set

LAD:															Applicable to	IVC2 IVC1
⊣⊢ ⊢[SET (D)]															Influenced flag bit	
IL: SET *(S)*															Program steps	1
Operand	Type	Applicable elements														Offset addressing
S	BOOL		Y	M	S	LM	SM				C	T				

Operand description

S: Source operand

Function description

When the power flow is valid, the bit element designated by ***D*** will be set.

Example

```
LD   M0
SET  M1
```

5.1.17 RST: Reset

LAD:															Applicable to	IVC2 IVC1
⊣⊢ ⊢[RST (D)]															Influenced flag bit	
IL: RST *(S)*															Program steps	1
Operand	Type	Applicable elements														Offset addressing
S	BOOL		Y	M	S	LM	SM				C	T				

Operand description

S: Source operand

Function description

When the power flow is valid, the designated bit element (D) will be reset

Example

```
LD   M0
RST  M1
```

Note

If D is C element, the corresponding count value will be reset; if D is T element, the corresponding timing value will be reset.

5.1.18 NOP: No Operation

LAD:	Applicable to	IVC2 IVC1
⊣⊢ ⊢[NOP]	Influenced flag bit	
IL: NOP	Program steps	1

Function description

This instruction does not enable any action.

Note

In LAD program, this instruction cannot directly connect to the left power flow bus.

5.2 Main Control Instruction

5.2.1 MC: Main Contorl

LAD:															Applicable to	IVC2 IVC1
⊣⊢ ⊢[MC (S)]															Influenced flag bit	
IL: MC *(S)*															Program steps	3
Operand	Type	Applicable elements														Offset addressing
S	INT	Constant														

Operand description

S: Source operand

5.2.2 MCR: Main Control Remove

LAD: ├──[MCR (S)]																Applicable to	IVC2 IVC1
																Influenced flag bit	
IL: MCR (S)																Program steps	1
Operand	Type	Applicable elements															Offset addressing
S	INT	Constant															

Operand description

S: Source operand

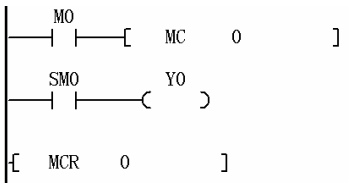
Function description

1. MC and MCR form a MC-MCR structure. The MC instruction indicates the beginning a MC-MCR structure, and its operand S is the SN of the MC-MCR structure. The value of S is a constant ranging from 0 to 7. MCR indicates the end of the MC-MCR structure.

2. When the power flow before the MC instruction is valid, the instructions in the MC-MCR structure will be executed.

3. When the power flow before the MC instruction is invalid, the program will skip over the instructions in the MC-MCR structure and execute the instructions after the structure. Besides, the destination operands of instructions OUT, TON, TOF, PWM, HCNT, PLSY,PLSR, DHSCS, SPD, DHSCI, DHSCR, DHSZ, DHST, DHSP and BOUT in the structure will be cleared.

Example




```
LD   M0
MC   0
LD   SM0
OUT  Y0
MCR  0
```

When M0 = ON, the instructions in the MC 0 - MCR 0 structure will be executed, and Y0 = ON. When M0 = OFF, the instructions in the MC 0 - MCR 0 structure will not be executed, and the bit element Y0 designated by the designation operand of the OUT instruction in the structure will be cleared, Y0 = OFF.

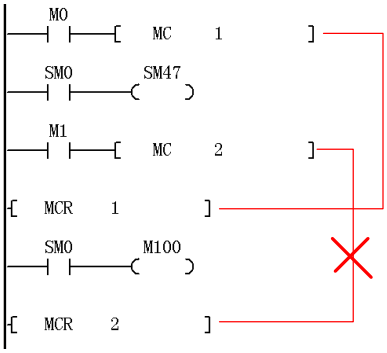
Note

1. In LAD program, the MCR instruction must directly connect to the left power flow bus.

2. In LAD program, the MCR instruction cannot connect to other instructions.

3. Several MC-MCR structures of different SNs can be used through the nest structure, but the number of nest levels cannot exceed 7. The MC-MCR structures with the same SN cannot be used in the nest structure.

4. Crossing of two MC-MCR structures is not allowed. The following is an illegal example.



Note: It cannot be used in SFC programming.

5.3 SFC Instructions

5.3.1 STL: SFC State Load Instruction

LAD:															Applicable to	IVC2 IVC1
															Influenced flag bit	
IL: STL *(S)*															Program steps	3
Operand	Type	Applicable elements														Offset addressing
S	BOOL						S									

Operand description

S : Source operand

Function description

1. It indicates the beginning of a step (***S***).

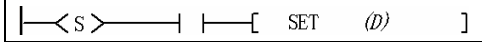
2. If a step is valid (ON), its embedded instructions will be executed.

3. If a step changes from ON to OFF (trailing edge), the embedded instructions will not be executed, and the destination operands of the embedded instructions such as OUT, TON, TOF, PWM, HCNT, PLSY, PLSR, DHSCS, SPD, DHSCI, DHSCR, DHSZ, DHST, DHSP and BOUT will be cleared.

4. If a step is invalid (OFF), the embedded instructions will not be executed.

5. Consecutive STL instructions (serial connection of S elements) define a parallel merge structure. The STL instructions can be used up to 16 times in a row (the maximum number of branches of a parallel branch structure is 16).

5.3.2 SET Sxx: SFC State Shift

LAD: 															Applicable to	IVC2 IVC1
															Influenced flag bit	
IL: SET *(D)*															Program steps	3
Operand	Type	Applicable elements														Offset addressing
D	BOOL						S									

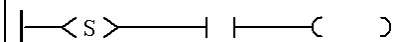
Operand description

D: Destination operand

Function description

When the power flow is valid, the designated step (***D***) will be set valid, and the current valid step will be set invalid, to complete the step transition.

5.3.3 OUT Sxx: SFC State Jump

LAD: 															Applicable to	IVC2 IVC1
															Influenced flag bit	
IL: OUT *(D)*															Program steps	3
Operand	Type	Applicable elements														Offset addressing
D	BOOL						S									

Operand description

D: Destination operand

Function description

When the power flow is valid, the designated step ***(D***) will be set valid, and the current valid step will be set invalid, to complete the step jump.

5.3.4 RST Sxx: SFC State Reset

LAD: [RST (D)]	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: RST *(D)*	Program steps	3

Operand	Type	Applicable elements													Offset addressing
D	BOOL						S								

Operand description

D: Destination operand

Function description

When the current power flow is valid, the designated step (***D***) will be set invalid.

5.3.5 RET: SFC Program End

LAD: [RET]	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: RET	Program steps	1

Function description

It indicates the end of a SFC program section.

Note

It can only be used in the main program.

5.4 Timer Instruction

5.4.1 TON: On-Delay Timing Instruction

LAD: [TON (D) (S)]	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: TON *(D)* *(S)*	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	INT											T			
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

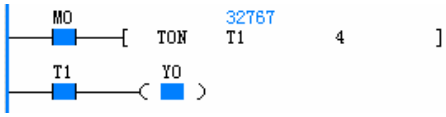
D: Destination operand

S: Source operand

Function description

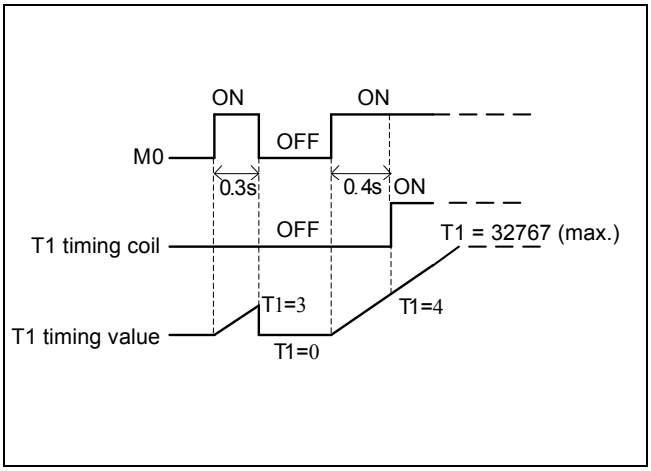
1. When the power flow is valid, and the timing value < 32,767, the designated T element (***D***) will start timing (the value will increase with the lapse of time). When the timing value reaches 32,767, it will maintain at 32,767.
2. When the timing value ≥ the preset value (***S***), the timing coil output of the designated T element will be ON.
3. When the power flow is OFF, the timing will stop, the timing value will be cleared, and the timing coil output will be OFF.
4. When the system executes the instruction for the first time, it will reset the timing coil of the designated T element, and clear the timing value.

Example




```
LD   M0
TON  T1  4
LD   T1
OUT  Y0
```

Time sequence chart



5.4.2 TONR: On-Delay Remember Timing Instruction

LAD: TONR (D) (S)															Applicable to	IVC2 IVC1
IL: TONR (D) (S)															Influenced flag bit	
															Program steps	5
Operand	Type	Applicable elements														Offset addressing
D	INT											T				
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√

Operand description

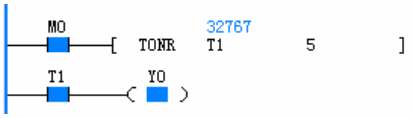
D: Destination operand

S: Source operand

Function description

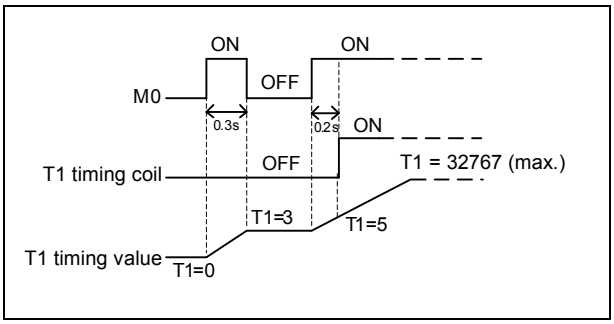
1. When the power flow is valid, and the timing value <32,767, the designated T element (***D***) start timing (the value will increase with the lapse of time). When the timing value reaches 32,767, it will maintain at 32,767.
2. When the timing value ≥ the preset value (***S***), the timing coil output of the designated T element will be ON.
3. When the power flow is OFF, the timing will stop, the timing coil and the timing value will maintain the current value.

Example




```
LD   M0
TONR T1  5
LD   T1
OUT  Y0
```

Time sequence chart



5.4.3 TOF: Off-Delay Timing Instruction

LAD: TOF (D) (S)															Applicable to	IVC2 IVC1
IL: TOF (D) (S)															Influenced flag bit	
															Program steps	5
Operand	Type	Applicable elements														Offset addressing
D	INT											T				
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√

Operand description

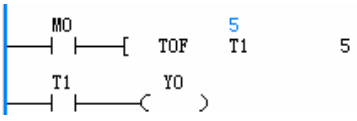
D: destination operand

S: Source operand

Function description

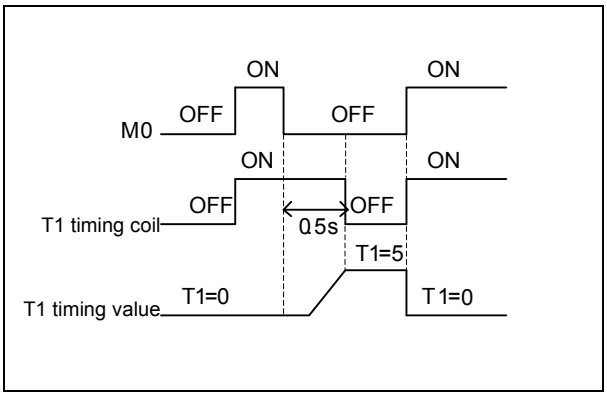
1. When the power flow changes from ON to OFF (trailing edge), the designated timer T (***D***) will start timing.
2. When the power flow is OFF, if the designated timer T has started timing, it will keep timing until the timing value reaches the preset value (***S***). The timing coil output of the T element will be OFF, and the timing value will maintain at the preset value.
3. When the power flow input is OFF, if the timing has not started, the timing will not start.
4. When the power flow is ON, the timing will stop, the timing value will be cleared, and the timing coil output is ON.

Example




```
LD   M0
TOF  T1  5
LD   T1
OUT  Y0
```

Sequence chart of example



5.4.4 TMON: Monostable Timing Instruction

LAD: TMON (D) (S)		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: TMON (D) (S)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	INT											T			
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

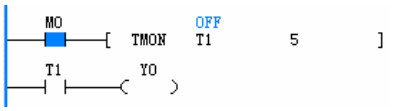
D: Destination operand

S: Source operand

Function description

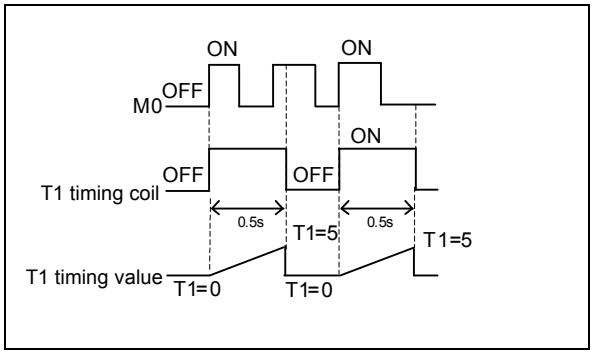
1. When the input power flow changes from OFF to ON (rising edge), and the timing has not started, the designated timer T (***D***) will start timing based on the current value. In the timing status (whose length is determined by ***S***), the timing coil output will maintain ON.
2. In the timing status (whose length is determined by ***S***), no matter how the power flow changes, the timing will keep going, and the timing coil output will keep ON.
3. When the timing value reaches the preset point, the timing will stop, the timing value will be cleared, and the timing coil output will be set OFF.

Example




```
LD   M0
TMON T1 5
LD   T1
OUT  Y0
```

Sequence chart of example



5.5 Counter Instruction

5.5.1 CTU: 16-Bit Counter Counting Up Instruction

LAD: CTU (D) (S)		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: CTU (D) (S)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	INT											C			
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D: destination operand

S: Source operand

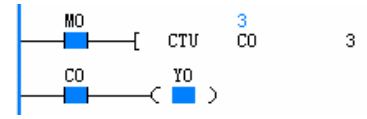
Function description

1. When the power flow changes from OFF to ON (rising edge), the 16-bit counter C (***D***) will count 1.
2. When the counting value reaches 32,767, it will maintain that value.
3. When the counting value is larger than or equal to the preset point (***S***), the counting coil will be set ON.

Note

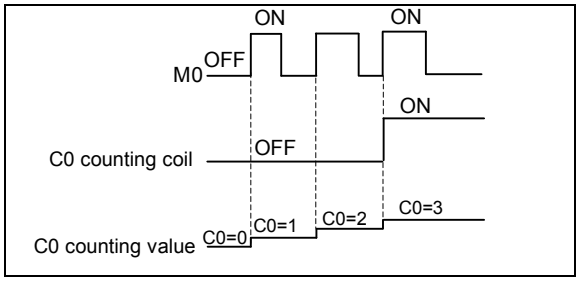
The address range of the 16-bit counter C (***D***): C0 ~ C199.

Example




```
LD   M0
CTU  C0 3
LD   C0
OUT  Y0
```

Time sequence chart



5.5.2 CTR: 16-Bit Counter Loop Cycle Counting Instruction

LAD: ⊣⊢ ⊢[CTR (D) (S)]		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: CTR (D) (S)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	INT											C			
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***D**:* destination operand

S: Source operand

Function description

1. When the power flow changes from OFF to ON (rising edge), the 16-bit counter C (***D***) will count 1.
2. When the counting value is equal to the preset point (***S***), the counting coil will be set ON.
3. After the counting value reaches the preset point (***S***), if the power flow changes from OFF to ON again (rising edge), the counting value will be set to 1, and the counting coil will be set OFF.

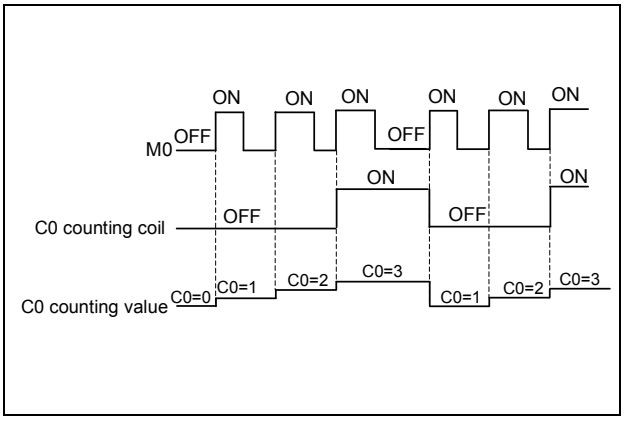
Note

1. When the preset counting value (***S***) is less than or equal to 0, there will be no counting.
2. The address of the 16-bit counter C (***D***) shall be within C0 ~ C199.

Example

```
LD   M0
CTR  C0  3
```

Time sequence chart



5.5.3 DCNT: 32-Bit Counting Instruction

LAD:	Applicable to	IVC2 IVC1
⊣⊢ ⊢[DCNT (D) (S)]	Influenced flag bit	
IL: DCNT (D) (S)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
D	DINT											C			
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D: destination operand

S: Source operand

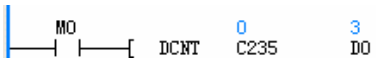
Function description

1. When the input power flow changes from OFF to ON (rising edge), the 32-bit counter C (***D***) will count up or down 1 (depending on the corresponding SM flag bit).
2. For a up counter, when the counting value is larger than or equal to the preset point (***S***), the counting coil will be set ON.
3. For a down counter, when the counting value is less than or equal to the preset point (***S***), the counting coil will be set OFF.
4. When the counting value is 2147483647, it will change to –2147483648 if the counter counts up once more.
5. When the counting value is -2147483648, it will change to 2147483647 if the counter counts down once more.

Note

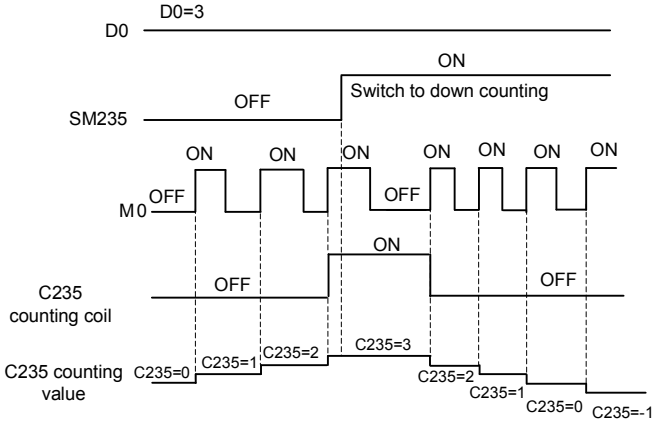
The address of the C element (***D***) shall be within C200 ~ C235.

Example




```
LD   M0
DCNT C235 D0
```

Time sequence chart



Chapter 6 Application Instructions

This chapter introduces the application instructions of IVC series small PLC, including the formats, operands, influenced flag bit, functions, examples and time sequence charts of the instructions.

6.1 Program Flow Control Instruction....75
6.1.1 FOR: Cycle Instruction....75
6.1.2 NEXT: Return From Cycle....75
6.1.3 LBL: Jump Label Definition....76
6.1.4 CJ: Conditional Jump....77
6.1.5 CFEND: Conditional End From User Main Program....77
6.1.6 WDT: User Program Watchdog Reset....78
6.1.7 EI: Enable Interrupt Instruction....78
6.1.8 DI: Disable Interrupt Instruction....78
6.1.9 CIRET: Conditional Return From User Interrupt Subprogram....78
6.1.10 STOP: User Program Stop....78
6.1.11 CALL: Calling A Subprogram....79
6.1.12 CSRET: Conditional Return From User Subprogram....79
6.2 Data Transmission Instruction....80
6.2.1 MOV: Move Word Data Transmission Instruction....80
6.2.2 DMOV: Move Double Word Data Transmission Instruction....80
6.2.3 RMOV: Move Floating Point Number Data Transmission....81
6.2.4 BMOV: Move Data Block Transmission Instruction....81
6.2.5 FMOV: Fill Data Block Instruction....82
6.2.6 DFMOV: Fill Data Block Double Word Instruction....82
6.2.7 SWAP: Swap Bytes....83
6.2.8 XCH: Exchange Word....83
6.2.9 DXCH: Exchange Double Word Instruction....84
6.2.10 PUSH: Push Instruction....84
6.2.11 FIFO: First-In-First-Out Instruction....85
6.2.12 LIFO: Last-In-First-Out Instruction....86
6.2.13 WSFR: Shift Right Word Instruction....87
6.2.14 WSFL: Shift Left Word Instruction....88
6.3 Integer Math Instructions....89
6.3.1 ADD: Add Integer Instruction....89
6.3.2 SUB: Subtract Integer Instruction....89
6.3.3 MUL: Multiply Integer Instruction....90
6.3.4 DIV: Divide Integer Instruction....90
6.3.5 SQT: Square Root Integer Instructions....91
6.3.6 INC: Increment Integer Instruction....91
6.3.7 DEC: Decrement Integer Instruction....92
6.3.8 VABS: Integer Absolute Value Instruction....92
6.3.9 NEG: Negative Integer Instruction....93
6.3.10 DADD: Add Double Integer Instruction....93
6.3.11 DSUB: Subtract Double Integer Instruction....94
6.3.12 DMUL: Multiply Double Integer Instruction....94
6.3.13 DDIV: Divide Double Integer Instruction....95
6.3.14 DSQT: Square Root Double Integer Instruction....95
6.3.15 DINC: Increment Double Integer Instruction....96

6.3.16 DDEC: Decrement Double Integer Instruction 96
6.3.17 DVABS: Double Integer Absolute Value Instruction 97
6.3.18 DNEG: Negative Double Integer Instruction 97
6.3.19 SUM: Sum Integer Instruction 98
6.3.20 DSUM: Sum Double Integer Instruction 99
6.4 Floating-Point Number Math Instruction 99
6.4.1 RADD: Add Floating Point Number Instruction 99
6.4.2 RSUB: Subtract Floating Point Number Instruction 100
6.4.3 RMUL: Multiply Floating Point Number Instruction 100
6.4.4 RDIV: Divide Floating Point Number Instruction 101
6.4.5 RSQT: Square Root Floating Point Number Instruction 101
6.4.6 RVABS: Floating Point Number Absolute Value Instruction 102
6.4.7 RNEG: Negative Floating Point Number Instruction 102
6.4.8 SIN: Floating Point Number Sin Instruction 103
6.4.9 COS: Floating Point Number COS Instruction 103
6.4.10 TAN: Floating Point Number TAN Instruction 104
6.4.11 POWER: Floating Point Number Exponentiation Instruction 104
6.4.12 LN: Floating Point Number LN Instruction 105
6.4.13 EXP: Floating Point Number EXP Instruction 105
6.4.14 RSUM: Sum Floating Point Number Instruction 106
6.5 Data Converting Instruction 106
6.5.1 DTI: Double Integer To Integer Instruction 106
6.5.2 ITD: Integer To Double Integer Instruction 107
6.5.3 FLT: Integer To Floating Point Number Instruction 107
6.5.4 DFLT: Double Integer To Floating Point Number Instruction 107
6.5.5 INT: Floating Point Number To Integer Instruction 108
6.5.6 DINT: Floating Point Number To Double Integer Instruction 108
6.5.7 BCD: Word To 16-Bit BCD Instruction 109
6.5.8 DBCD: Double Word To 32-Bit BCD Instruction 109
6.5.9 BIN: 16-Bit BCD To Word Instruction 110
6.5.10 DBIN: 32-Bit BCD To Double Word Instruction 110
6.5.11 GRY: Word To 16-bit Gray Code Instruction 111
6.5.12 DGRY: Double Word To 32-Bit Gray Code Instruction 111
6.5.13 GBIN: 16-Bit Gray Code To Word Instruction 112
6.5.14 DGBIN: 32-Bit Gray Code To Double Word Instruction 112
6.5.15 SEGI: Word To 7-Segment Encode 113
6.5.16 ASC: ASCII Code Conversion Instruction 113
6.5.17 ITA: Hexadecimal Integer-ASCII Conversion Instruction 114
6.5.18 ATI: ASCII-Hexadecimal Integer Conversion Instruction 115
6.6 Word Logic Operation 115
6.6.1 WAND: AND Word Instruction 115
6.6.2 WOR: OR Word Instruction 116
6.6.3 WXOR: Exclusive-OR Word Instruction 116
6.6.4 WINV: NOT Word Instruction 117
6.6.5 DWAND: AND Double Word Instruction 117
6.6.6 DWOR: OR Double Word Instruction 118
6.6.7 DWXOR: Exclusive-OR Double Word Instruction 118
6.6.8 DWINV: NOT Double Word Instruction 119
6.7 Shift / Rotate Instruction 119
6.7.1 ROR: 16-Bit Circular Shift Right Instruction 119

6.7.2 ROL: 16-Bit Circular Shift Left Instruction 120
6.7.3 RCR: 16-Bit Carry Circular Shift Right Instruction 121
6.7.4 RCL: 16-Bit Carry Circular Shift Left Instruction 122
6.7.5 DROR: 32-Bit Circular Shift Right Instruction 122
6.7.6 DROL: 32-Bit Circular Shift Left Instruction 123
6.7.7 DRCR: 32-Bit Carry Circular Shift Right Instruction 123
6.7.8 DRCL: 32-Bit Carry Circular Shift Left Instruction 124
6.7.9 SHR: 16-Bit Shift Right Word Instruction 124
6.7.10 SHL: 16-Bit Shift Left Instruction 125
6.7.11 DSHR: 32-Bit Shift Right Instruction 125
6.7.12 DSHL: 32-Bit Shift Left Instruction 126
6.7.13 SFTR: Shift Right Byte Instruction 127
6.7.14 SFTL: Shift Left Byte Instruction 128
6.8 External Equipment Instruction 129
6.8.1 FROM: Read Word Form Special Module Buffer Register Instruction 129
6.8.2 DFROM: Read Double Word Form Special Module Buffer Register Instruction 130
6.8.3 TO: Write Word To Special Module Buffer Register Instruction 131
6.8.4 DTO: Write Double Word To Special Module Buffer Register Instruction 132
6.8.5 VRRD: Read Analog Potentiometer Value Instruction 132
6.8.6 REFF: Set Input Filtering Constant Instruction 133
6.8.7 REF: Instant Refresh I/O Instruction 133
6.8.8 EROMWR: EEPROM Write Instruction 134
6.9 Real-Time Clock Instruction 135
6.9.1 TRD: Read Real-Time Clock Instruction 135
6.9.2 TWR: Write Real-Time Clock Instruction 136
6.9.3 TADD: Add Clock Instruction 137
6.9.4 TSUB: Subtract Clock Instruction 138
6.9.5 HOUR: Timing List Instruction 139
6.9.6 DCMP: Compare Date (=, <, >, <>, >=, <=) Instruction 140
6.9.7 TCMP: Compare Time (=, <, >, <>, >=, <=) Instruction 141
6.10 High-speed I/O Instruction 142
6.10.1 HCNT: High-speed Counter Drive Instruction 142
6.10.2 DHSCS: High-speed Counting Compare Set Instruction 143
6.10.3 DHSCI: High-speed Counting Compare Interrupt Trigger Instruction 144
6.10.4 DHSCR: High-speed Counting Compare Reset Instruction 145
6.10.5 DHSZ: High-speed Counting Zone Compare Instruction 146
6.10.6 DHST: High-speed Counting Table Compare Instruction 147
6.10.7 DHSP: High-speed Counting Table Compare Pulse Output Instruction 149
6.10.8 SPD: Pulse Detection Instruction 151
6.10.9 PLSY: Count Pulse Output Instruction 152
6.10.10 PLSR: Count Pulse With Acceleration/Deceleration Output Instruction 153
6.10.11 PLS: Pulse Output Instruction of Envelope 155
6.10.12 PWM: Pulse Output Instruction 156
6.11 Control Calculation Instruction 157
6.11.1 PID: PID Instruction 157
6.11.2 RAMP: Ramp Wave Signal Output Instruction 160
6.11.3 HACKLE: Hackle Wave Signal Output Instruction 161
6.11.4 TRIANGLE: Triangle Wave Signal Output Instruction 162
6.12 Communication Instruction 164
6.12.1 Modbus: Modbus Master Station Communication Instruction 164

6.12.2 IVFWD: FREQUENCY CONVERTER Forward Rotation Instruction....165
6.12.3 IVREV: FREQUENCY CONVERTER Reverse Rotation Instruction....166
6.12.4 IVDFWD: FREQUENCY CONVERTER Touch Forward Rotation Instruction....166
6.12.5 IVDREV: FREQUENCY CONVERTER Touch Reverse Rotation Instruction....167
6.12.6 IVSTOP: FREQUENCY CONVERTER Stop Instruction....167
6.12.7 IVFRQ: FREQUENCY CONVERTER Set Frequency Instruction....168
6.12.8 IVWRT: FREQUENCY CONVERTER Write Single Register Value Instruction....169
6.12.9 IVRDST: FREQUENCY CONVERTER Read Status Instruction....170
6.12.10 IVRD: FREQUENCY CONVERTER Read Single Register Value Instruction....171
6.12.11 XMT: Free-Port Sending (XMT) Instruction....172
6.12.12 RCV: Free-Port Receiving (RCV) Instruction....173
6.13 Data Check Instruction....174
6.13.1 CCITT: Check Instruction....174
6.13.2 CRC16: Check Instruction....175
6.13.3 LRC: Check Instruction....176
6.14 Enhanced Bit Processing Instruction....177
6.14.1 ZRST: Batch Bit Reset Instruction....177
6.14.2 ZSET: Set Batch Bit Instruction....177
6.14.3 DECO: Decode Instruction....178
6.14.4 ENCO: Encode Instruction....178
6.14.5 BITS: Counting ON Bit In Word Instruction....179
6.14.6 DBITS: Counting ON Bit In Double Word Instruction....179
6.15 Word Contactor Instruction....180
6.15.1 BLD: Word Bit Contactor LD Instruction....180
6.15.2 BLDI: Word Bit Contactor LDI Instruction....180
6.15.3 BAND: Word Bit Contactor AND Instruction....181
6.15.4 BANI: Word Bit Contactor AND Instruction....181
6.15.5 BOR: Word Bit Contactor OR Instruction....182
6.15.6 BORI: Word Bit Contactor ORI Instruction....182
6.15.7 BOUT: Word Bit Coil Output Instruction....183
6.15.8 BSET: Word Bit Coil Set Instruction....183
6.15.9 BRST: Word Bit Coil Reset Instruction....183
6.16 Compare Contactor Instrucitons....184
6.16.1 Compare Integer LD (=, <, >, <>, >=, <=) Instrucitons....184
6.16.2 Compare Integer AND (=, <, >, <>, >=, <=) Instruction....185
6.16.3 Compare Integer OR (=, <, >, <>, >=, <=) Instruction....186
6.16.4 Compare Double Integer LDD (=, <, >, <>, >=, <=) Instruction....187
6.16.5 Compare Double Integer ANDD (=, <, >, <>, >=, <=) Instruction....188
6.16.6 Compare Double Integer ORD (=, <, >, <>, >=, <=) Instruction....189
6.16.7 Compare Floating Point Number LDR Instruction....190
6.16.8 Compare Floating Point Number ANDR Instruction....191
6.16.9 Compare Floating Point Number ORR Instruction....192
6.17 Locating Instructions....193
6.17.1 Setting Up An Absolute Position System....193
6.17.2 Overview Of Locating Instructions For IVC Series PLC....193
6.17.3 Mechanical Diagram Of Absolute Position System....194
6.17.4 Points To Note For Using Locating instructions ZRN, PLSV, DRVI And DRVA....194
6.17.5 Notes On Servo Amplifiers....195
6.17.6 Special Elements Related To Locating instructions....195
6.17.7 ZRN: Regress To Origin Instruction....196

6.17.8 PLSV: Variable Speed Pulse Output Instruction 197
6.17.9 DRVI: Relative Position Control Instruction 198
6.17.10 DRVA: Control Absolute Position Instruction 199
6.17.11 ABS: Read Current Value Instruction 199
6.17.12 Application Examples 201

6.1 Program Flow Control Instruction

6.1.1 FOR: Cycle Instruction

LAD: [FOR (S)]	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: FOR (S)	Program steps	3

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: Source operand

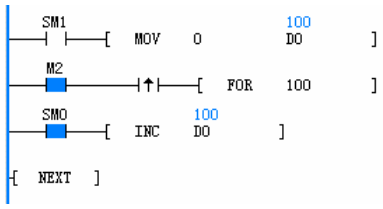
6.1.2 NEXT: Return From Cycle

LAD: [NEXT]	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: NEXT	Program steps	1

Function description

1. Instructions FOR and NEXT form a FOR-NEXT structure.
2. When the power flow before FOR is valid, and the cycle times (***S***) is larger than 0, the instructions in the FOR-NEXT structure will be cyclically executed ***S*** times. After that, the instructions after the FOR-NEXT structure will be executed.
3. If the power flow before FOR is invalid, or the cycle times (***S***) is less than or equal to 0, the program will skip over the instructions in the FOR-NEXT structure and execute the following instructions.

Example

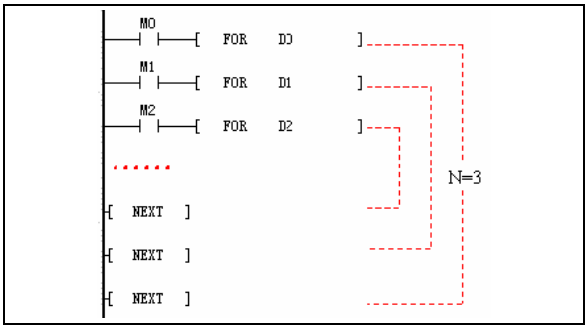



```
LD   SM1
MOV  0   D0
LD   M2
EU
FOR  100
LD   SM0
INC  D100
NEXT
```

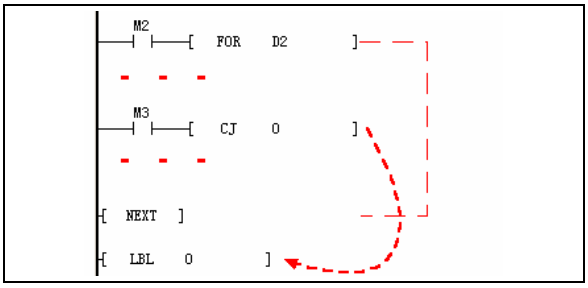
The initial conditions for the operation are: D0=0, M2=OFF. When M2 changes from OFF to ON, the instructions in the FOR-NEXT structure will be consecutively executed for 100 times. D0 will increase one for each cycle. When the cycle is over, D0 reaches 100.

Note

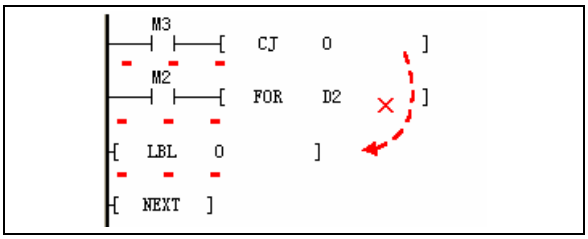
1. The FOR-NEXT instruction must be used in pairs in a POU, or the program cannot pass the compiling.
2. Nesting of several FOR-NEXT structures is supported. IVC2 series PLC supports up to 8 levels of nesting. (The figure below shows a 3-level nesting of FOR-NEXT structure)



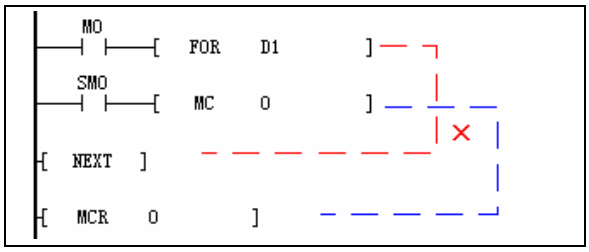
3. You can use the Conditional Jump (CJ) instruction to jump out of the structure and end the loop in advance, as shown in the following ladder diagram:



4. It is prohibited to use the CJ instruction to jump into a loop. The LAD program shown in the following figure cannot pass the compiling.



5. The crossing of the structures MC-MCR and FOR-NEXT is prohibited. LAD program shown in the following figure cannot pass the compiling.



Note

The execution of the FOR-NEXT structure is time consuming. The bigger the cycle times is, or the more instructions are contained in the loop, the longer it will take. To prevent the operation overtime error, use the WDT instruction in a time-consuming loop.

6.1.3 LBL: Jump Label Definition

LAD: [LBL (S)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: LBL (S)	**Program steps**	**3**

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant													

Operand description

S: label number. Range: 0 ≤ **S** ≤ 127

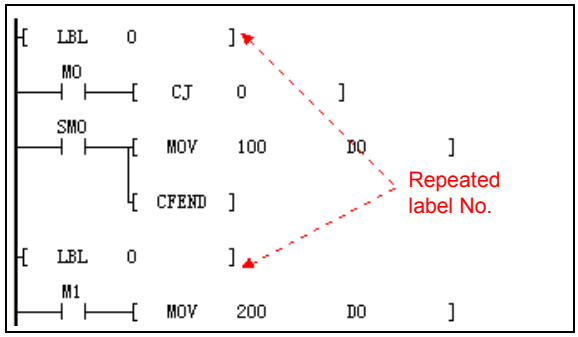
Function description

1. A label numbered ***S*** is defined.
2. It is used to mark a specific jumping position for the CJ instruction.

Note

Take care not to mark two labels with the same No. in one POU, or the program cannot pass the compiling. However, you can do so in different POUs (for example, different sub-programs).

Example of error program



6.1.4 CJ: Conditional Jump

LAD:																Applicable to	IVC2 IVC1
⊣⊢ ⊢[CJ (S)]																Influenced flag bit	
IL: CJ (S)																Program steps	3
Operand	Type	Applicable elements															Offset addressing
S	INT	Constant															

Operand description

S: label SN

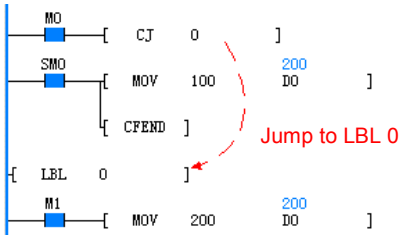
Function description

1. When the power flow is valid, the program will jump to execute the instruction numbered ***S***.
2. If the power flow is invalid, the program will not jump, but execute the instruction following CJ.

Note

1. The jumping label ***S*** (0 ≤ **S** ≤ 127) for the CJ instruction shall be a legal and defined label. Otherwise, the user program cannot pass the compiling.
2. It is not allowed to use the CJ instruction to jump into a FOR-NEXT structure.
3. It is allowable to use the CJ instruction to jump out of or into the MC-MCR structure or SFC status. However, such operation will damage the logic of the MC-MCR structure or SFC status and make the program complex. It is not recommended to do this.

Example




```
LD   M0
CJ   0
LD   SM0
MOV 100   D0
CFEND
LBL   0
LD   M1
MOV 200   D0
```

1. Initial conditions: M0=OFF, M1=ON. The CJ instruction is not be executed, and D0 is 100. After executing CFEND, the current cycle of the main program ends in advance, and the following LD and MOV instructions are not executed.
2. When M0 is ON, M1=ON, the program will execute the CJ instruction, skip over the “MOV 100 200” and CFEND instructions, and jump to LBL 0 and execute “MOV 200 D0” instruction. D0 is 200 then.

6.1.5 CFEND: Conditional End From User Main Program

LAD:	Applicable to	IVC2 IVC1
⊣⊢ ⊢[CFEND]	Influenced flag bit	
IL: CFEND	Program steps	1

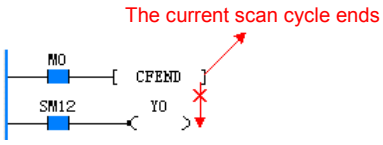
Function description

1. When the power flow of the instruction is valid, the current scan cycle of the main program ends immediately and the following instructions in the main program will not be executed.
2. When the power flow of the instruction is invalid, the instruction enables no action, and the instruction after it will be executed in order.

Note

The CFEND must be used in the main program, or the program cannot pass the compiling.

Example




```
LD   M0
CFEND
LD   SM12
OUT   Y0
```

When the program is running, if M0=OFF, the CFEND instruction will not enable any action. The following instructions LD and OUT will be executed. When M0 is ON, the CFEND instruction will be executed, the main program will end the current scan cycle immediately, and the following instructions will not be executed.

6.1.6 WDT: User Program Watchdog Reset

LAD:	Applicable to	IVC2 IVC1
├─┤ ├─[WDT]	Influenced flag bit	
IL: WDT	Program steps	1

Function description

When the power flow is valid, the instruction will clear the user program watchdog, and the watchdog will restart timing.

6.1.7 EI: Enable Interrupt Instruction

LAD:	Applicable to	IVC2 IVC1
├─┤ ├─[EI]	Influenced flag bit	
IL: EI	Program steps	1

Function description

1. When the power flow of the EI instruction is valid, the interrupts in the current scan cycle will be enabled.
2. When the EI instruction is valid, the interrupt requests will be allowed to join the interrupt request queue to wait for system response.

6.1.8 DI: Disable Interrupt Instruction

LAD:	Applicable to	IVC2 IVC1
├─┤ ├─[DI]	Influenced flag bit	
IL: DI	Program steps	1

Function description

1. When the power flow is valid, the global interrupt enable flag is inactive, that is, the global interrupt will be off.
2. When the global interrupt enable flag is inactive, the interrupt events will not generate any interrupt request.

Note

When the DI instruction is valid, the system will still respond to the unprocessed interrupt requests in the request queue, but new interrupt events cannot generate interrupt requests.

6.1.9 CIRET: Conditional Return From User Interrupt Subprogram

LAD:	Applicable to	IVC2 IVC1
├─┤ ├─[CIRET]	Influenced flag bit	
IL: CIRET	Program steps	1

Function description

When the power flow is valid, the system will quit the current interrupt program immediately.

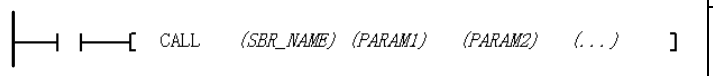
6.1.10 STOP: User Program Stop

LAD:	Applicable to	IVC2 IVC1
├─┤ ├─[STOP]	Influenced flag bit	
IL: STOP	Program steps	1

Function description

When the power flow is valid, the system will immediately stop the execution of the user program.

6.1.11 CALL: Calling A Subprogram

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: CALL (SBR name) (PARAM1) (PARAM2) …	Program steps	Determined by the subprogram parameters

Function description

When the power flow is valid, the system will call the designated subprogram, execute it, and then return to the main program to execute the instructions following the CALL instruction.

Note

1. The subprogram called by the CALL instruction must be defined in advance in the user program, or the program cannot pass the compiling.

2. The operand element type in the CALL instruction must match the **Data Type** defined in the local variable table of the subprogram, or the program cannot pass the compiling.

The following examples demonstrates some illegal matches.

Example 1: In the local variable table of subprogram SBR1, the data type of Operand 1 is DINT/DWORD.

The following usages are illegal:

- CALL SBR1 Z0 (The data type of Z element cannot be DINT/DWORD)
- CALL SBR1 C199 (The data type of elements C0 to C199 cannot be DINT/DWORD)
- CALL SBR1 K2X0 (Kn addressing 1 ≤ n ≤ 3, the data type cannot be DINT/DWORD)

Example 2: In the local variable table of the SBR1 subprogram, the data type of Operand 1 is INT/WORD, the following usages are illegal:

- CALL SBR1 C200 (The data type of element C200 to C255 cannot be INT/WORD)
- CALL SBR1 K2X0 (Kn addressing 4 ≤ n ≤ 8, the data type cannot be INT/WORD)

3. The operand element type in the CALL instruction must match the **Variable Type** defined in the local variable table in the subprogram, or the program will not pass the compiling.

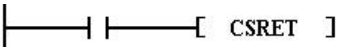
The following examples demonstrates some illegal matches.

Example: In the local variable table of subprogram SBR1, the operand type of Operand 1 is OUT or IN_OUT, the following usages are illegal:

- CALL SBR1 321 (constants cannot be changed, therefore it does not match OUT or IN_OUT)
- CALL SBR1 K4X0 (K4X0 is read-only, therefore it does not match OUT or IN_OUT)
- CALL SBR1 SD0 (SD0 is read-only, therefore it does not match OUT or IN_OUT)

4. The number of the operands in the CALL instruction must match the local variable table of the subprogram, or the program will not pass the compiling.

6.1.12 CSRET: Conditional Return From User Subprogram

LAD:	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: CSRET	Program steps	1

Function description

When the power flow is valid, the program will quit the current subprogram and return to the upper level subprogram.

6.2 Data Transmission Instruction

6.2.1 MOV: Move Word Data Transmission Instruction

LAD: MOV (S) (D)									Applicable to			IVC2 IVC1			
									Influenced flag bit						
IL: MOV (S) (D)									Program steps			5			
Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D	SD	C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, the content of ***S*** is assigned to ***D***, and the value of S remains unchanged.

Note

1. The MOV instruction supports signed and unsigned integers. If the two operands are both elements, the data type is signed integer. If the source operand is a signed integer (for example, -10, +100), the destination operand is also a signed integer. If the source operand is an unsigned double integer (for example, 100, or 45535), the destination operand will also be an unsigned integer.
2. The corresponding element C only supports C0 to C199.

Example

```
LD   X0
MOV  D0   D10
```

When X0 is ON, the content of D0 is assigned to D10, D10 = 500.

6.2.2 DMOV: Move Double Word Data Transmission Instruction

LAD: DMOV (S) (D)									Applicable to			IVC2 IVC1			
									Influenced flag bit						
IL: DMOV (S) (D)									Program steps			7			
Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	DINT			KnY	KnM	KnS	KnLM		D	SD	C		V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, the content of ***S*** is assigned to ***D***, and the value of ***S*** remains unchanged.

Note

1. The DMOV instruction supports signed and unsigned double integers. If the two operands of the instruction are elements, the data types are signed integers. If the source operand of the instruction is a signed double integer (for example, -10, +100), the destination operand will also be signed integer. If the source operand is the unsigned double integer (for example, 100, 45535), the destination operand will also be unsigned integer.
2. The corresponding element C only supports C200 to C255.

Example

```
LD   X0
DMOV D0   D10
```

When X0 is ON, the content of (D0, D1) is assigned to (D10, D11). (D10, D11) is 50000.

6.2.3 RMOV: Move Floating Point Number Data Transmission

LAD: RMOV (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: RMOV (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, the content of ***S*** is assigned to ***D***, and the value of ***S*** remains unchanged.

Example

```
LD   X0
RMOV D0
D10
```

When X0 is ON, the content of (D0, D1) is assigned to (D10, D11). (D10, D11) is 50000.5.

6.2.4 BMOV: Move Data Block Transmission Instruction

LAD: BMOV (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BMOV (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT		KnX	KnY	KnM	KnS	KnLM		D	SD	C	T	V		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: Source operand, starting element of data block;

D: Destination operand, starting element of data block;

S2: size of data block

Function description

When the power flow is valid, the contents of ***S2*** elements starting with ***S1*** are assigned to the ***S2*** elements starting with ***D***, and the contents of ***S2*** elements starting with ***S1*** remain unchanged.

Example

```
LD   X0
BMOV D0  D100  10
```

When X0 is ON, the contents of 10 elements starting with D0 are assigned to 10 elements starting with D100. D100 = D0, D101 = D1, ..., D109 = D9.

6.2.5 FMOV: Fill Data Block Instruction

LAD: FMOV (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: FMOV (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand, starting element of data block;

D: Destination operand, starting element of data block;

S2: size of data block

Function description

When the power flow is valid, the contents of ***S1*** will be filled into ***S2*** elements starting with ***D*** element, and the content of ***S1*** remains unchanged.

Note

1. When ***S1***, ***D*** and ***S2*** use C element, the legal range is C0 to C199.
2. ***S2*** is larger than or equal to 0.
3. When ***S1*** and ***D*** both use Kn addressing, Kn shall be the same.

Example

```
LD   X0
FMOV D0 D100 10
```

When X0 is ON, the content of D0 will be filled into 10 elements starting with D100. D100 = D101 = ... = D109 = D0 = 500.

6.2.6 DFMOV: Fill Data Block Double Word Instruction

LAD: DFMOV (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DFMOV (S1) (D) (S2)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand

D: Destination operand, starting element of data block

S2: size of data block

Function description

When the power flow is valid, the contents of ***S1*** will be filled into ***S2*** elements starting with ***D***, and the content of ***S1*** remains unchanged.

Note

1. When ***S1***, ***D*** and ***S2*** use C element, the legal range is C200 to C255.
2. ***S2*** is larger than or equal to 0.
3. When ***S1*** and ***D*** are both Kn addressing, Kn shall be the same.

Example

```
LD    X0
DFMOV D0 D10 10
```

When X0 is ON, the content of (D0, D1) will be filled into 10 × 2 units starting with D10. (D10, D11) = (D12, D13) =...= (D28, D29) = (D0, D1) = 100000.

6.2.7 SWAP: Swap Bytes

LAD: SWAP (D)		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: SWAP (D)		Program steps	3

Operand	Type	Applicable elements													Offset addressing
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

D: Destination operand, the word element whose high/low bytes are swapped.

Function description

When the power flow is valid, the ***D*** element whose high/low bytes has been swapped will be saved.

Example

```
LD   X0
SWAP D0
```

When X0 is ON, the high/low bytes in D0 = 0x1027 (4135) will be swapped and saved. D0 is then 0x2710 (10000).

6.2.8 XCH: Exchange Word

LAD: XCH (D1) (D2)		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: XCH (D1) (D2)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
D1	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
D2	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

D1: destination operand 1

D2: destination operand 2

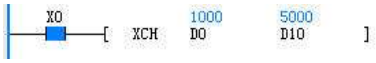
Function description

When the power flow is valid, ***D1*** and ***D2*** will exchange their values.

Note

When using the Kn addressing mode, the Kn in ***D1*** and ***D2*** shall be the same.

Example




```
LD   X0
XCH D0   D10
```

When X0 is ON, D0 and D10 will exchange their values. Before the execution, D0 is 5000 and D10 is 1000. After the execution, D0 is 1000 and D10 is 5000.

6.2.9 DXCH: Exchange Double Word Instruction

LAD: DXCH (D1) (D2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DXCH (D1) (D2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
D1	DINT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
D2	DINT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

D1: destination operand 1

D2: destination operand 2

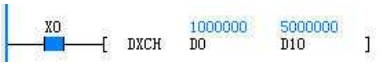
Function description

When the power flow is valid, ***D1*** and ***D2*** will exchange their values.

Note

When using the Kn addressing mode, the Kn in ***D1*** and ***D2*** shall be the same.

Example




```
LD X0
DXCH D0 D10
```

When X0 is ON, D0 and D10 will exchange their values. Before the execution and (D0, D1) is 5000000, (D10, D11) is 1000000. After the execution, (D0, D1) is 1000000 and (D10, D11) is 5000000.

6.2.10 PUSH: Push Instruction

LAD: PUSH (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: PUSH (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT								D				V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: push value

D: the number of elements in the stack. It is also the element at the stack bottom.

S2: stack size

Function description

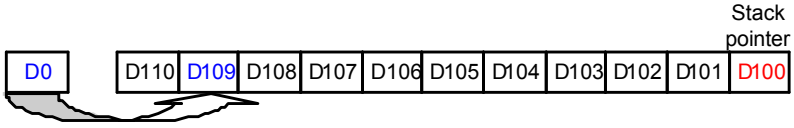
1. When the power flow is valid, the value of ***S1*** will be pushed onto the top of the stack with ***D*** element as the bottom, and ***D*** will increase by 1. At this time, the address of the stack top unit is the address of ***D*** plus the value of ***D***.
2. When the value of ***D*** reaches ***S2***, one more push instruction will set the operation carry flag (SM181) to 1, and the push operation will not be executed.

Note

1. When the stack is illegal (for example, when the stack size ≤ 0, the number of elements in the stack < 0, or when the stack size is beyond the limit), the system will report “Definition error of stack operated”.
2. The stack size does not include the stack bottom element (the element designated by ***D***).
3. ***S2*** indicates the stack size. Range: ≥ 0.

Example

```
LD M0
PUSH D0 D100 10
```



1. When M0 is ON, push D0 into the stack with D100 as the stack bottom.
2. Before the execution, D0 is 1000, D100 is 8 and D109 is 0.
3. After the execution, D0 is 1000, D100 is 9 and D109 is 1000.

6.2.11 FIFO: First-In-First-Out Instruction

LAD:		Applicable to	IVC2 IVC1
⊣⊢ ⊣⊢[FIFO (D1) (D2) (S)]		Influenced flag bit	
IL: FIFO (*D1*) (*D2*) (*S*)		Program steps	7

Operand	Type	Applicable elements													Offset addressing
D1	INT								D				V		√
D2	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D1: the number of elements in the stack. Its element address plus 1 is the address of the stack head.

D2: storage register for popped value

S: queue size

Function description

1. When the power flow is valid, the value of the stack head (the element immediately following D1) with D1 as the queue head is assigned to D2. At the same time, the value of D1 subtracts 1, the contents of the ***S*** units after D1 will move forward, and the last unit is filled with 0.

2. When ***D1*** is 0, it indicates that the stack is empty, the zero flag (SM180) will be set 1.

Note

1. When the stack is illegal (for example, when the stack size ≤ 0, the number of elements in the stack < 0, or when the stack size is beyond the limit), the system will report “Definition error of stack operated”.

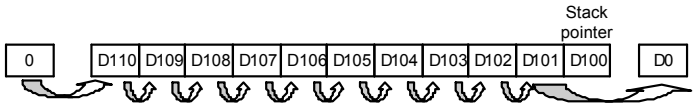
2. The stack size does not include the stack bottom element (the element designated by ***D1***)

3. ***S*** indicates the stack size. Range: ≥ 0.

Example

LD M0

FIFO D100 D0 10



1. When M0 is ON, the content of D101 is filled into D0, and at the same time the contents of D101 ~ D110 move forward, and the D110 is filled with 0.

2. Before the execution: D0 = 0, D100 = 10, D101 = 1000, D102 = 2000, ..., D109 = 9000, D110 = 10000.

3. After the execution: D0 = 1000, D100 = 9, D101 = 2000, D102 = 3000,..., D109 = 10000, D110 = 0.

6.2.12 LIFO: Last-In-First-Out Instruction

LAD:	Applicable to	IVC2 IVC1
⊣⊢ ⊣⊢[LIFO (D1) (D2) (S)]	Influenced flag bit	
IL: LIFO (*D1*) (*D2*) (*S*)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
D1	INT								D				V		√
D2	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D1: the number of elements in the queue. Its element address plus 1 is the address of the queue's head.

D2*:* storage register for popped value

S: queue size

Function description

1. When the power flow is valid, the value of the stack head with D1 as the stack bottom is assigned to D2, and at the same time the value of D1 subtracts 1.
2. When D1 is 0, it indicates that the stack is empty, the zero flag (SM180) will be set 1.

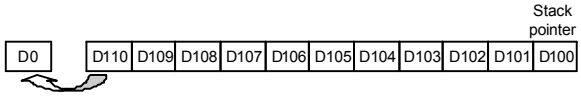
Note

1. When the stack is illegal (for example, when the stack size ≤ 0, the number of elements in the stack < 0, or when the stack size is beyond the limit), the system will report "Definition error of stack operated".
2. The stack size does not include the stack bottom element (the element designated by ***D1***)
3. ***S*** indicates the stack size. Range: ≥ 0.

Example

LD M0

LIFO D100 D0 10



1. When M0 is ON, the content of D110 is assigned to D0, the content of units D101 ~ D110 remain unchanged.
2. Before the execution: D0 = 0, D100 = 10, D101 = 1000, D102 = 2000, ..., D109 = 9000, D110 = 10000.
3. After the execution: D0 = 10000, D100 = 9, D101 = 1000, D102 = 2000, ..., D109 = 9000, D110 = 10000.

6.2.13 WSFR: Shift Right Word Instruction

LAD: WSFR (S1) (D) (S2) (S3)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: WSFR (*S1*) (*D*) (*S2*) (*S3*)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	INT		KnX	KnY	KnM	KnS	KnLM		D	SD	C	T	V		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand

D: Destination operand, starting unit of word string

S2*:* size of destination word queue

S3*:* number of words filled rightward

Function description

When the power flow is valid, the contents of ***S2*** units starting with ***D*** unit will move rightward ***S3*** words. The rightmost ***S3*** units will be discarded. At the same time, the contents of ***S3*** units starting with ***S1*** will be filled into the left end of the word string.

Note

1. The elements with smaller SN are at the right, and the elements with larger SN are at the left.

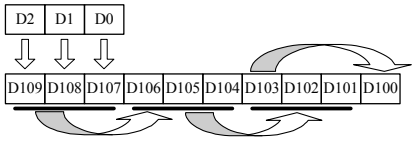
2. ***S2*** ≥ 0, ***S3*** ≥ 0, ***S2*** ≥ ***S3***.

3. When ***S1*** and ***D*** both use Kn addressing, Kn shall be the same.

Example

LD X0

WSFR D0 D100 10 3



1. When M0 is ON, the contents of 10 units starting with D100 unit will move rightward 3 words. The rightmost units D102 ~ D100 will be discarded. At the same time, the contents of the 3 units starting with D0 will be filled into the left end of the word string.

2. Before the execution: D2=300, D1=200, D0=100. D109=10000, D108=9000, D107=8000, D106=7000, D105=6000, D104=5000, D103=4000, D102=3000, D101=2000, D100=1000.

3. After the execution: D0 ~ D2 remain unchanged, D2=300, D1=200, D0=100. D109=300, D108=200, D107=100, D106=10000, D105=9000, D104=8000, D103=7000, D102=6000, D101=5000, D100=4000.

..

6.2.14 WSFL: Shift Left Word Instruction

LAD: WSFL (S1) (D) (S2) (S3)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: WSFL (S1) (D) (S2) (S3)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	INT		KnX	KnY	KnM	KnS	KnLM		D	SD	C	T	V		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: source operand

D: destination operand, starting unit of word string

S2*:* size of destination word queue

S3*:* number of words filled for right forward

Function description

When the power flow is valid, the contents of ***S2*** units starting with ***D*** unit will move leftward ***S3*** words. The leftmost ***S3*** units will be discarded. At the same time, the contents of ***S3*** units starting with ***S1*** will be filled into the right end of the word string.

Note

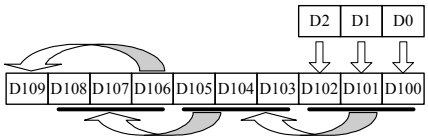
1. The elements with smaller SN are at the right, and the elements with larger SN are at the left.

2. ***S2*** ≥ 0, ***S3*** ≥ 0, ***S2*** ≥ ***S3***.

3. When ***S1*** and ***D*** both use Kn addressing, Kn shall be the same.

Example

```
LD   X0
WSFL D0 D100 10 3
```



1. When X0 is ON, the contents of 10 units starting with D100 will move leftward 3 words. The leftmost units D109 ~ D107 will be discarded. At the same time, the contents of the 3 units starting with D0 will be filled into the right end of the word string.

2. Before the execution: D0=100, D1=200, D2=300. D109=10000, D108=9000, D107=8000, D106=7000, D105=6000, D104=5000, D103=4000, D102=3000, D101=2000, D100=1000

3. After the execution: D0 ~ D2 remain unchanged: D2=300, D1=200, D0=100. D109=7000, D108=6000, D107=5000, D106=4000, D105=3000, D104=2000, D103=1000, D102=300, D101=200, D100=100.

6.3 Integer Math Instructions

6.3.1 ADD: Add Integer Instruction

LAD: ADD (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: ADD (S1) (S2) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, add ***S1*** and ***S2***, and assign the operation result to ***D***.
2. When the operation result (***D***) is larger than 32767, the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set. When the operation result is less than –32768, the borrow flag bit (SM182) will be set.

Example

LD X0

ADD D0 D1 D10

When X0 is ON, add D0 (1000) and D1 (2000), and assign the result to D10, D10 = 3000.

6.3.2 SUB: Subtract Integer Instruction

LAD: SUB (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: SUB (S1) (S2) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, S1 subtracts S2, and the operation result is assigned to ***D***.
2. When the operation result (***D***) is larger than 32767, the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set. When the operation result is less than –32768, the borrow flag will be set bit (SM182).

Example

LD X0

SUB D0 D1 D10

When X0 is ON, D0 (1000) subtracts D1 (2000), and the result –1000 is assigned to D10.

6.3.3 MUL: Multiply Integer Instruction

LAD: MUL (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: MUL (S1) (S2) (D)	Program steps	8

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

When the power flow is valid, ***S1*** multiplies ***S2***, and the operation result is assigned to ***D***.

Note

The operation result of MUL instruction is a 32-bit data.

Example

LD X0

MUL D0 D1 D10

When X0 is ON, D0 (1000) multiplies D1 (2000), and the result 2000000 is assigned to (D10, D11).

6.3.4 DIV: Divide Integer Instruction

LAD: DIV (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DIV (S1) (S2) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

When the power flow is valid, ***S1*** is divided by ***S2***, and the operation result is assigned to ***D*** (***D*** includes 2 units, one storing the quotient, the other storing the remainder).

Note

S2 ≠ 0, otherwise, the system will report “Divided by 0 error”, and the instruction will not be executed.

Example

LD X0

DIV D0 D1 D10

When X0 is ON, D0 (2500) is divided by D1 (1000), the result is assigned to (D10, D11). D10=2, D11=500.

6.3.5 SQT: Square Root Integer Instructions

LAD: SQT (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: SQT (S) (D)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, ***S*** is extracted, and the operation result is assigned to ***D***.
2. When the operation result (***D***) is 0, the zero flag bit (SM180) will be set. When the operation result rounds off the decimal fraction, the borrow flag bit (SM182) will be set.

Note

S ≥ 0, otherwise, the system will report operand error, and the instruction will not be executed.

Example

```
LD   X0
SQT  D0  D10
```

When X0 is ON, extract D0 (1000), and assign the result to D10, D10=31.

6.3.6 INC: Increment Integer Instruction

LAD: INC (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: INC (D)	Program steps	3

Operand	Type	Applicable elements													Offset addressing
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

D: Destination operand

Function description

When the power flow is valid, ***D*** increases by 1.

Note

1. This instruction is a cyclic increase instruction. Range: –32768 ~ 32767.
2. The supported range of C element: C0 ~ C199.

Example

```
LD   X0
INC  D0
```

When X0 is ON, D0 (1000) is increased by 1. After the execution, D0 is 1001.

6.3.7 DEC: Decrement Integer Instruction

LAD: DEC (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: DEC (D)															Program steps	3
Operand	Type	Applicable elements														Offset addressing
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z		√

Operand description

D: Destination operand

Function description

When the power flow is valid, ***D*** decreases 1.

Note

This instruction is a cyclic decrease instruction, with the range of –32768 ~ 32767.

Example

```
LD   X0
DEC  D0
```

When X0 is ON, D0 (1000) decreases 1. After the execution, D0=999.

6.3.8 VABS: Integer Absolute Value Instruction

LAD: VABS (S) (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: VABS (S) (D)															Program steps	5
Operand	Type	Applicable elements														Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z		√

Operand description

S: Source operand

D: Destination operand

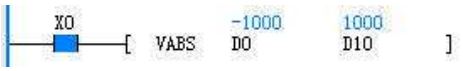
Function description

When the power flow is valid, get the absolute value of ***S*** and assign it to ***D***.

Note

The range of ***S*** shall be -32767 ~ 32767. When ***S*** is -32768, the system will report operand error, and the instruction will not be executed.

Example




```
LD   X0
VABS D0  D10
```

When X0 is ON, get the absolute value of D0 (-1000), and assign the result to D10. D10=1000.

6.3.9 NEG: Negative Integer Instruction

LAD:	Applicable to	IVC2 IVC1
⊣⊢ [NEG (S) (D)]	Influenced flag bit	Zero, carry, borrow
IL: NEG (*S*) (*D*)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

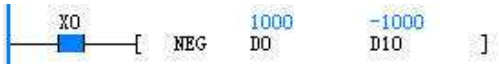
Function description

When the power flow is valid, get the negative value of ***S*** and assign the result to ***D***.

Note

The range of ***S*** shall be –32767 ~ 32767. When ***S*** is –32768, the system will report operand error, and the instruction will not be executed.

Example




```
LD X0
NEG D0 D10
```

When X0 is ON, get the negative value of D0 (1000) and assign the result to D10. D10=-1000.

6.3.10 DADD: Add Double Integer Instruction

LAD:	Applicable to	IVC2 IVC1
⊣⊢ [DADD (S1) (S2) (D)]	Influenced flag bit	Zero, carry, borrow
IL: DADD (*S1*) (*S2*) (*D*)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

***S1*:** Source operand 1

S2: Source operand 2

D: destination operand

Function description

1. When the power flow is valid, add S1 and S2, and assign the operation result to ***D***.
2. When the operation result (***D***) > 2147483647, the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set. When the operation result < -2147483648, the borrow flag bit (SM182) will be set.

Example

```
LD X0
DADD D0 D2 D10
```

When X0 I ON, add the value (100000) of (D0, D1) and the value (200000) of (D2, D3), and assign the result to (D10, D11). (D10, D11) = 300000.

6.3.11 DSUB: Subtract Double Integer Instruction

LAD: DSUB (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DSUB (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, S1 subtracts S2, and the operation result is assigned to **D**.
2. When the operation result (**D**) > 2147483647, the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set. When the operation result < -2147483648, the borrow flag bit (SM182) will be set.

Example

LD X0

DSUB D0 D2 D10

When X0 is ON, the value (100000) of (D0, D1) subtracts the value (200000) of (D2,D3), and the result –100000 is assigned to (D10, D11).

6.3.12 DMUL: Multiply Double Integer Instruction

LAD: DMUL (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DMUL (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

When the power flow is valid, ***S1*** multiplies ***S2***, and the result is assigned to ***D***.

Note

The result of the DMUL instruction is a 32-bit data, and overflow may occur.

Example

LD X0

DMUL D0 D2 D10

When X0 is ON, the value (83000) of (D0, D1) multiplies the value (2000) of (D2,D3), and the result 1660000000 is assigned to (D10, D11).

6.3.13 DDIV: Divide Double Integer Instruction

LAD: DDIV (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DDIV (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

When the power flow is valid, ***S1*** is divided by ***S2***, and the operation result is assigned to ***D*** (***D*** includes 4 units, with the first two storing the quotient, the other two storing the remainder)

Note

S2 ≠ 0, otherwise, the system will report “Divided by 0 error”, and the instruction will not be executed.

Example

```
LD   X0
DDIV D0  D2  D10
```

When X0 is ON, the value (83000) of (D0, D1) is divided by the value (2000) of (D2, D3), and the result is assigned to (D10, D11) and (D12,D13). (D10, D11) = 41, (D12, D13) = 1000.

6.3.14 DSQT: Square Root Double Integer Instruction

LAD: DSQT (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DSQT (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

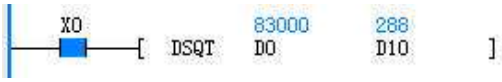
Function description

1. When the power flow is valid, ***S*** is extracted, and the operation result is assigned to ***D***.
2. When the operation result (***D***) is 0, the zero flag bit (SM180) will be set. When the operation result rounds off the decimal fraction, the borrow flag bit (SM182) will be set.

Note

S ≥ 0, otherwise, the system will report operand error, and the instruction will not be executed.

Example




```
LD   X0
DSQT D0  D10
```

When X0 is ON, extract the value (83000) of (D0, D1), and assign the result to (D10, D11). (D10, D11) = 288.

6.3.15 DINC: Increment Double Integer Instruction

LAD: DINC (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: DINC (D)															Program steps	4
Operand	Type	Applicable elements														Offset addressing
D	DINT			KnY	KnM	KnS	KnLM		D		C		V			√

Operand description

D: Destination operand

Function description

When the power flow is valid, ***D*** increases 1.

Note

1. This instruction is a cyclic increase instruction. Range: -2147483648 ~ 2147483647.
2. The supported range of C element: C200 ~ C255.

Example

```
LD   X0
DINC D0
```

When X0 is ON, the value (100000) of (D0, D1) increases 1. After the execution, (D0, D1) = 100001.

6.3.16 DDEC: Decrement Double Integer Instruction

LAD: DDEC (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: DDEC (D)															Program steps	4
Operand	Type	Applicable elements														Offset addressing
D	DINT			KnY	KnM	KnS	KnLM		D		C		V			√

Operand description

D: Destination operand

Function description

When the power flow is valid, ***D*** decreases 1.

Note

This instruction is a cyclic decrease instruction. Range: -2147483648 ~ 2147483647

Example

```
LD   X0
DDEC D0
```

When X0 is ON, the value (100000) of (D0, D1) decreases 1. After the execution, (D0, D1) = 99999.

6.3.17 DVABS: Double Integer Absolute Value Instruction

LAD: DVABS (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DVABS (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

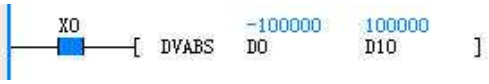
Function description

When the power flow is valid, get the absolute value of ***S*** and assign the result to ***D***.

Note

The range of ***S*** shall be -2147483647 ~ 2147483647. When S is -2147483648, the system will report operand error, and the instruction will not be executed.

Example




```
LD   X0
DVABS  D0   D10
```

When X0 is ON, get the absolute value (100000) of (D0, D1) and assign the result to (D10, D11). (D10, D11) = 100000.

6.3.18 DNEG: Negative Double Integer Instruction

LAD: DNEG (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DNEG (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, get the negative value of ***S*** and assign the result to ***D***.

Note

The range of S shall be -2147483647 ~ 2147483647. When the value of ***S*** is -2147483648, the system will report operand error, and the instruction will not be executed.

Example

```
LD   X0
DNEG   D0   D10
```

When X0 is ON, get the negative value (-100000) of (D0, D1), and assign the result to (D10, D11). (D10, D11) = -100000.

6.3.19 SUM: Sum Integer Instruction

LAD:	Applicable to	IVC2 IVC1
⊣⊢ ⊣[SUM (S1) (S2) (D)]	Influenced flag bit	Zero, carry, borrow
IL: SUM (S1) (S2) (D)	Program steps	8

Operand	Type	Applicable elements													Offset addressing
S1	INT		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand, starting unit of summing

S2 *:* Source operand, number of units to be summed up

D: Destination operand, summing result

Function description

When the power flow is valid, the contents of ***S2*** units starting with the starting unit (***S1***) will be summed up, and the summing result is assigned to the ***D*** unit.

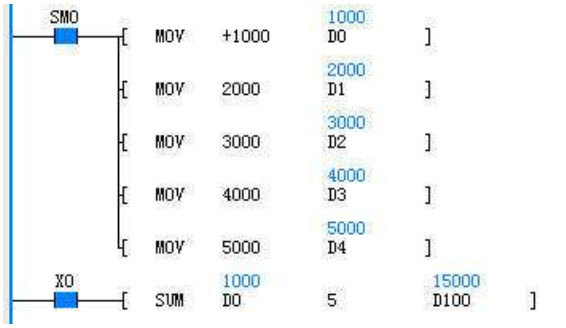
Note

1. The operation result of the SUM instruction is a 32-bit data.

2. 0 ≤ ***S2*** ≤ 255, or system will report operand error..

3. Since ***D*** is a 32-bit data, the carry and borrow flags are constantly 0, and the zero flag is determined by the final summing result.

Example




```
LD   SM0
MOV  1000  D0
MOV  2000  D1
MOV  3000  D2
MOV  4000  D3
MOV  5000  D4
LD   X0
SUM  D0  5  D100
```

When X0 is ON, the integers of 5 elements starting form ***D0*** will be summed up, and the result is assigned to (D100, D101), (D100, D101) = D0+...+D4 = 15000.

6.3.20 DSUM: Sum Double Integer Instruction

LAD: DSUM (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DSUM (*S1*) (*S2*) (*D*)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DINT		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand, starting unit of summing

S2: Source operand, number of data to be summed up

D: destination operand, summing result

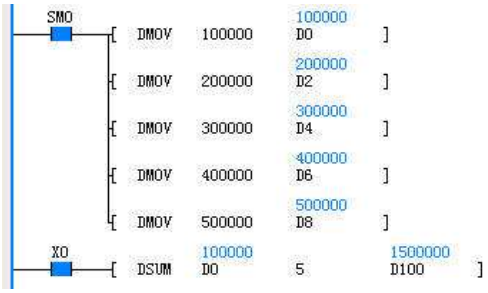
Function description

When the power flow is valid, the contents of ***S2*** × 2 units starting with the starting unit (***S1***) will be summed up, and the summing result is assigned to the ***D*** unit.

Note

0 ≤ ***S2*** ≤ 255, or the system will report operand error.

Example




```
LD   SM0
DMOV 100000 D0
DMOV 200000 D2
DMOV 300000 D4
DMOV 400000 D6
DMOV 500000 D8
LD   X0
DSUM D0 5 D100
```

When X0 is ON, the double integers of 5 × 2 units starting with D0 will be summed up, and the result is assigned to (D100, D101).

6.4 Floating-Point Number Math Instruction

6.4.1 RADD: Add Floating Point Number Instruction

LAD: RADD (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RADD (*S1*) (*S2*) (*D*)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, add ***S1*** and ***S2***, and assign the operation result to ***D***.

2. When the operation result (***D***) is not within (-1.701412e + 038) ~ (1.701412e + 038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example

```
LD   X0
RADD D0 D2 D10
```

When X0 is ON, add the value (-10000.2) of (D0, D1) and the value (2000.5) of (D2, D3), and the result -7999.7 is assigned to (D10, D11).

6.4.2 RSUB: Subtract Floating Point Number Instruction

LAD: RSUB (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RSUB (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand 1

S2: Source operand 2

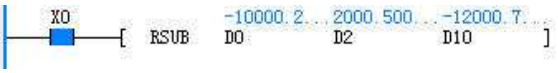
D: Destination operand

Function description

1. When the power flow is valid, ***S2*** is subtracted from ***S1***, and the operation result is assigned to ***D***.

2. When the operation result (***D***) is not within (-1.701412e + 038) ~ (1.701412e + 038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example



LD X0

RSUB D0 D2 D10

When X0 is ON, the value (2000.5) of (D2, D3) is subtracted from the value (-10000.2) of (D0, D1), and the result -12000.7 is assigned to (D10, D11).

6.4.3 RMUL: Multiply Floating Point Number Instruction

LAD: RMUL (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RMUL (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, ***S1*** multiplies ***S2***, and the operation result is assigned to ***D***.

2. When the operation result (***D***) is not within (-1.701412e + 038) ~ (1.701412e + 038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example

LD X0

RMUL D0 D2 D10

When X0 is ON, the value (-10000.2) of (D0, D1), multiplies the value (2000.5) of (D2, D3), and the result -20005400.0 is assigned to (D10, D11) (actually the product is -20005400.1, but is rounded off to the calculation precision).

6.4.4 RDIV: Divide Floating Point Number Instruction

LAD: RDIV (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RDIV (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, ***S1*** is divided by ***S2***, and the operation result is assigned to ***D*** (which includes 4 units, with the first two storing the quotient, the other two storing the remainder)
2. When the operation result (***D***) is not within (-1.701412e + 038) ~ (1.701412e + 038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Note

S2 ≠ 0, or the system will report "Divided by 0 error", and the RDIV instruction will not be executed.

Example

LD X0

RDIV D0 D2 D10

When X0 is ON, the value -10000.2 of (D0, D1) is divided by the value 2000.5 of (D2, D3), and the result -4.998850 is assigned to (D10, D11).

6.4.5 RSQT: Square Root Floating Point Number Instruction

LAD: RSQT (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RSQT (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, ***S*** is extracted, and the operation result is assigned to ***D***.
2. When the operation result (***D***) is 0, the zero flag bit (SM180) will be set.

Note

S ≥ 0, or the system will report operand error, and the instruction will not be executed.

Example

LD X0

RSQT D0 D10

When X0 is ON, extract the value (10000.2) of (D0, D1), and assign the result 100.000999 to (D10, D11).

6.4.6 RVABS: Floating Point Number Absolute Value Instruction

LAD: RVABS (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RVABS (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

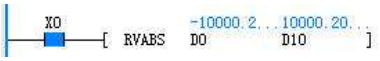
S: Source operand

D: Destination operand

Function description

When the power flow is valid, get the absolute value of ***S*** and assign the value to ***D***.

Example



LD X0

RVABS D0 D10

When X0 is ON, get the absolute value (10000.2) of (D0, D1), and assign the result to (D10, D11).

6.4.7 RNEG: Negative Floating Point Number Instruction

LAD: RNEG (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RNEG (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, get the negative value of ***S*** and assign the result to ***D***.

Example

LD X0

RNEG D0 D10

When X0 is ON, get the negative value -10000.2 of (D0, D1) and assign the result to (D10, D11).

6.4.8 SIN: Floating Point Number Sin Instruction

LAD: SIN (S) (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: SIN (S) (D)															Program steps	7
Operand	Type	Applicable elements														Offset addressing
S	REAL	Constant							D				V			√
D	REAL								D				V			√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, get the SIN value of ***S*** (unit: radian), and assign the result to ***D***.
2. When the operation result (***D***) is 0, the zero flag bit (SM180) will be set.

Example

LD X0

SIN D0 D10

When X0 is ON, get the SIN value of (D0, D1) =1.57, and assign the value 1 to (D10, D11).

6.4.9 COS: Floating Point Number COS Instruction

LAD: COS (S) (D)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: COS (S) (D)															Program steps	7
Operand	Type	Applicable elements														Offset addressing
S	REAL	Constant							D				V			√
D	REAL								D				V			√

Operand description

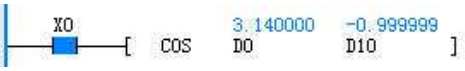
S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, get the COS value of ***S*** (unit: radian), and assign the result to ***D***.
2. When the operation result (***D***) is 0, the zero flag bit (SM180) will be set.

Example



LD X0

COS D0 D10

When X0 is ON, get the COS value of (D0, D1) 3.14, and assign the result -0.999999 to (D10, D11).

6.4.10 TAN: Floating Point Number TAN Instruction

LAD: TAN (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: TAN (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

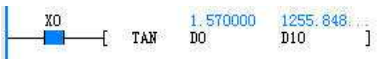
S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, get the TAN value of ***S*** (unit: radian), and assign the result to ***D***.
2. When the operation result (***D***) is not within (-1.701412e + 038) ~ (1.701412e + 038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example




```
LD   X0
TAN  D0  D10
```

When X0 is ON, get the TAN value of (D0, D1) 1.57, and assign the result 1255.848398 to (D10, D11).

6.4.11 POWER: Floating Point Number Exponentiation Instruction

LAD: POWER (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: POWER (S1) (S2) (D)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand 1

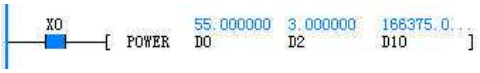
S2: Source operand 2

D: Destination operand

Function description

1. When the power flow is valid, get the ***S2***th power of ***S1***, and assign the result to ***D***.
2. When the operation result (***D***) is not within (-1.701412e+038) ~ (1.701412e+038), the carry flag bit (SM181) will be set.
3. When the operation result is 0, the zero flag bit (SM180) will be set.

Example




```
LD    X0
POWER D0 D2 D10
```

When X0 is ON, get the (D2, D3)th power of (D0, D1) (i.e. $55.0^{3.0}$), and assign the result 166375.0 to (D10, D11).

Note

1. When ***S1*** = 0 and ***S2*** ≤ 0, the system will report operand error, and the instruction will not be executed.
2. When ***S1*** < 0 and the mantissa of ***S2*** is not 0, the system will report operand error, and the instruction will not be executed.

6.4.12 LN: Floating Point Number LN Instruction

LAD: LN (S) (D)										Applicable to		IVC2 IVC1						
										Influenced flag bit		Zero, carry, borrow						
IL: LN (S) (D)										Program steps		7						
Operand	Type	Applicable elements																Offset addressing
S	REAL	Constant							D				V					√
D	REAL								D				V					√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, get the LN value of ***S1***, and assign the result to ***D***.
2. When the operation result (***D***) is not within (-1.701412e+038) ~ (1.701412e+038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example

```
LD   X0
LN   D0   D10
```

When X0 is ON, get the LN value of (D0, D1) 1000.0, and assign the result 6.907755 to (D10, D11).

6.4.13 EXP: Floating Point Number EXP Instruction

LAD: EXP (S) (D)										Applicable to		IVC2 IVC1						
										Influenced flag bit		Zero, carry, borrow						
IL: EXP (S) (D)										Program steps		7						
Operand	Type	Applicable elements																Offset addressing
S	REAL	Constant							D				V					√
D	REAL								D				V					√

Operand description

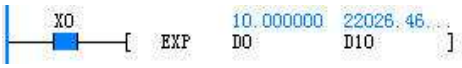
S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, get the EXP value of ***S***, and assign the result to ***D***.
2. When the operation result (***D***) is not within (-1.701412e+038) ~ (1.701412e+038), the carry flag bit (SM181) will be set. When the operation result is 0, the zero flag bit (SM180) will be set.

Example




```
LD   X0
EXP  D0   D10
```

When X0 is ON, get the EXP value of (D0, D1) “10.0”, and assign the result 22026.464844 to (D10, D11).

6.4.14 RSUM: Sum Floating Point Number Instruction

LAD: RSUM (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: RSUM (S1) (S2) (D)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	REAL								D				V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D				V		√
D	REAL								D				V		√

Operand description

S1: Source operand, starting unit of summing

S2: Source operand, number of units to be summed up

D: Destination operand, summing result

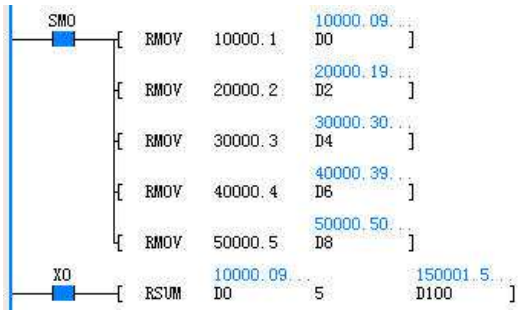
Function description

When the power flow is valid, the contents of ***S2*** × 2 units starting with ***S1*** will be summed up, and the floating point number summing result is assigned to the ***D*** unit.

Note

1. 0 ≤ ***S2*** ≤ 255, or the system will report operand error.
2. When overflow occurs, the summing operation will stop.

Example




```
LD   SM0
RMOV 10000.1 D0
RMOV 20000.2 D2
RMOV 30000.3 D4
RMOV 40000.4 D6
RMOV 50000.5 D8
LD   X0
RSUM D0 5
D100
```

When X0 is ON, the floating point numbers of the 5 × 2 units starting with ***D0*** will be summed up, and the result is assigned to (D100, D101). (D100, D101) = (D0, D1) + ... + (D8, D9) = 150001.5.

6.5 Data Converting Instruction

6.5.1 DTI: Double Integer To Integer Instruction

LAD: DTI (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DTI (S) (D)	Program steps	6

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from double integer to integer, and the result is assigned to ***D***.

Note

When ***S*** is not within –32768 ~ 32767, the system will report operand error and will not execute the conversion. ***D*** will not change.

Example

```
LD   X0
DTI  D0  D10
```

When X0 is ON, (D0, D1) 10000 will be converted from double integer to integer and the result 10000 is assigned to D10.

6.5.2 ITD: Integer To Double Integer Instruction

LAD: ITD (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: ITD (S) (D)	Program steps	6

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

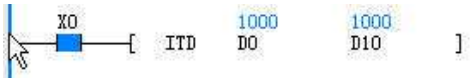
S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to double integer, and the result is assigned to ***D***.

Example




```
LD   X0
ITD  D0   D10
```

When X0 is ON, D0 (1000) will be converted from integer to double integer, and the result 1000 is assigned to (D10, D11).

6.5.3 FLT: Integer To Floating Point Number Instruction

LAD: FLT (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: FLT (S) (D)	Program steps	6

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	REAL								D				V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to floating point number, and the result is assigned to ***D***.

Example

```
LD
X0
FLT
D0
D10
```

When X0 is ON, D0 (10005) will be converted from integer to floating point number, and the result 10005.0 is assigned to (D10, D11).

6.5.4 DFLT: Double Integer To Floating Point Number Instruction

LAD: DFLT (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DFLT (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	REAL								D				V		√

Operand description

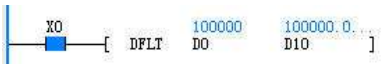
S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from double integer to floating point number, and the result is assigned to ***D***.

Example




```
LD   X0
DFLT D0   D10
```

When X0 is ON, (D0, D1) 100000 will be converted from integer to floating point number, and the result 100000.0 is assigned to (D10, D11).

6.5.5 INT: Floating Point Number To Integer Instruction

LAD: ⊣⊢ ⊣⊢[INT (S) (D)]	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: INT (S) (D)	Program steps	6

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	INT			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, ***S*** will be converted from floating point number to integer, and the result is assigned to ***D***.
2. This instruction affects the zero flag and borrow flag. When the conversion result is 0, the zero flag will be set. When the result rounds off the decimal fraction, the borrow flag will be set. the carry (overflow) flag will be set.

Note

When ***S*** > 32767, ***D***=32767. When ***S***<-32768, ***D*** = -32768, and at the same time the carry (overflow) flag bit will be set.

Example

```
LD   X0
INT  D0  D10
```

When X0 is ON, (D0, D1) 10000.5 will be converted from floating point number to integer and the result 10000 is assigned to D10.

6.5.6 DINT: Floating Point Number To Double Integer Instruction

LAD: ⊣⊢ ⊣⊢[DINT (S) (D)]	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: DINT (S) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	REAL	Constant							D				V		√
D	DINT			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

Function description

1. When the power flow is valid, ***S*** will be converted from floating point number to double integer, and the result is assigned to ***D***.
2. When the conversion result is 0, the zero flag will be set. When the result rounds off the decimal fraction, the borrow flag will be set. When the result exceeds the range of the double integer, the carry (overflow) flag will be set.

Note

When ***S*** > 2147483647, ***D*** = 2147483647. When ***S*** < -2147483648, ***D*** = -2147483648, and at the same time the carry (overflow) flag will be set.

Example

```
LD   X0
DINT D0  D10
```

When X0 is ON, (D0, D1) 100000.5 will be converted from floating point number to double integer, and the result 100000 is assigned to (D10, D11).

6.5.7 BCD: Word To 16-Bit BCD Instruction

LAD: ⊣⊢ ⊢[BCD (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: BCD (S) (D)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand. ***S*** ≤ 9999
D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to 16-bit BCD code, and the result is assigned to ***D***.

Note

When ***S*** > 9999, the system will report operand error and will not execute the instruction, and ***D*** will not change.

Example

```
LD   X0
BCD  D0  D10
```

When X0 is ON, D0 0x0D05 (3333) will be converted from integer to 16-bit BCD code, and the result 0x3333 (13107) is assigned to D10.

6.5.8 DBCD: Double Word To 32-Bit BCD Instruction

LAD: ⊢[DBCD (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: DBCD (S) (D)		Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand, ***S*** ≤ 99999999

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to 32-bit BCD code, and the result is assigned to ***D***.

Note

When ***S*** > 99999999, the system will report operand error and will not execute the instruction, and ***D*** will not change.

Example

```
LD   X0
DBCD D0  D10
```

When X0 is ON, (D0, D1) 0x3F940AA (66666666) will be converted from double integer to 32-bit BCD code, and the result 0x66666666 (1717986918) is assigned to (D10, D11).

6.5.9 BIN: 16-Bit BCD To Word Instruction

LAD: [BIN (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: BIN (S) (D)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand, the data format of ***S*** must match the BCD code format

D: Destination operand

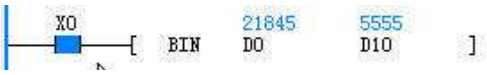
Function description

When the power flow is valid, ***S*** will be converted from 16-bit BCD code to integer, and the result is assigned to ***D***.

Note

When the data format of ***S*** does not match the BCD code format, the system will reports illegal operand and will not execute the instruction, and ***D*** will not change.

Example




```
LD   X0
BIN  D0  D10
```

When X0 is ON, D0 0x5555 (21845) will be converted from 16-bit BCD code to integer, and the result 0x15B3 (5555) is assigned to D10.

6.5.10 DBIN: 32-Bit BCD To Double Word Instruction

LAD: ⊣⊢ [DBIN (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: DBIN (S) (D)		Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

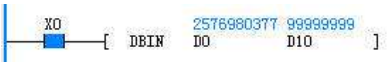
Function description

1. When the power flow is valid, ***S*** will be converted from 16-bit BCD code to double integer, and the result is assigned to ***D***.
2. The data format of ***S*** must match the BCD code format.

Note

When the data format of ***S*** does not match the BCD code format, the system will report operand error and will not execute the instruction, and D will not change.

Example




```
LD   X0
DBIN D0  D10
```

When X0 is ON, (D0, D1) 0x99999999 (2576980377) will be converted from 32-bit BCD code to double integer, and the result 0x5F5E0FF (99999999) is assigned to (D10, D11).

6.5.11 GRY: Word To 16-bit Gray Code Instruction

LAD: [GRY (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: GRY (S) (D)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

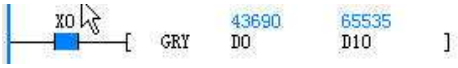
S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to 16-bit Gray code, and the result is assigned to ***D***.

Example




```
LD   X0
GRY  D0  D10
```

When X0 is ON, D0 0xAAAA (43690) will be converted form integer to 16-bit Gray code, and the result 0xFFFF (65535) is assigned to D10.

6.5.12 DGRY: Double Word To 32-Bit Gray Code Instruction

LAD: ⊣⊢ [DGRY (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: DGRY (S) (D)		Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to 32-bit Gray code, and the result is assigned to ***D***.

Example

```
LD   X0
DGRY D0  D10
```

When X0 is ON, (D0, D1) 0x88888888 (2290649224) will be converted from double integer to 32-bit Gray code, and the result 0xCCCCCCCC (3435973836) is assigned to (D10, D11).

6.5.13 GBIN: 16-Bit Gray Code To Word Instruction

LAD: ├─┤ ├─[GBIN (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: GBIN (S) (D)		Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from 16-bit Gray code to integer, and the result is assigned to ***D***.

Example

```
LD   X0
GBIN D0  D10
```

When X0 is ON, D0 0xFFFF (65535) will be converted from 16-bit Gray code to integer, and the result 0xAAAA (43690) is assigned to D10.

6.5.14 DGBIN: 32-Bit Gray Code To Double Word Instruction

LAD: ├─┤ ├─[DGBIN (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	Zero, carry, borrow
IL: DGBIN (S) (D)		Program steps	7

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

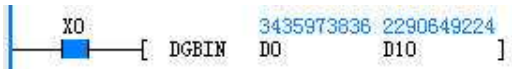
S: Source operand

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from 32-bit Gray code to double integer, and the result is assigned to ***D***.

Example




```
LD   X0
DGBIN D0  D10
```

When X0 is ON, (D0, D1) 0xCCCCCCCC (3435973836) will be converted from 32-bit Gray code to double integer, and the result 0x88888888 (2290649224) is assigned to (D10, D11).

6.5.15 SEGI: Word To 7-Segment Encode

LAD: SEG (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: SEG (S) (D)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S: Source operand, ***S*** ≤ 15

D: Destination operand

Function description

When the power flow is valid, ***S*** will be converted from integer to 7-segment code, and the result is assigned to ***D***.

Note

When ***S***>15, the system reports illegal operand and will not execute the instruction, and ***D*** will not change.

Example

```
LD   X0
SEG  D0  D10
```

When X0 is ON, D0 0x0F (15) will be converted from integer to 7-segment code, and the result 0x71 (113) is assigned to D10.

6.5.16 ASC: ASCII Code Conversion Instruction

LAD: ASC (S1 ~ S8) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: ASC (S1 ~ S8) (D)	Program steps	19

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant													
S2	WORD	Constant													
S3	WORD	Constant													
S4	WORD	Constant													
S5	WORD	Constant													
S6	WORD	Constant													
S7	WORD	Constant													
S8	WORD	Constant													
D	WORD								D		C	T	V	Z	√

Operand description

S1 **~** ***S8*** : Source operand (If the number is less than 8, the remaining elements shall be filled with 0)

Only characters with ASCII code of 0x21 ~ 0x7E are supported (input through keyboard, if the number is less than 8, fill in with 0X00)

D: destination operand

Function description

When the power flow is valid, the string ***S1*** **~** ***S8*** will be converted to ASCII code, and the result is assigned to the elements starting with ***D***. When SM186 isOFF, the high/low byte of each D element will store two ASCII code data. When SM186 is ON, the low byte of each D element will store 1 ASCII code data.

Example

```
LD   M0
ASC  12345678  D0
```

When M0 is ON, execute the ASCII conversion, and the data will be stored in two modes:

- When SM186 is OFF, the execution result is: D0=0x3231, D1=0x3433, D2=0x3635, D3=0x3837.
- When SM186 is ON, the execution result is: D0=0x31, D1=0x32, D2=0x33, D3=0x34, D4=0x35, D5=0x36, D6=0x37, D7=0x38.

6.5.17 ITA: Hexadecimal Integer-ASCII Conversion Instruction

LAD: ITA (S1) (D) (S2)															Applicable to	IVC2 IVC1
															Influenced flag bit	Zero, carry, borrow
IL: ITA (S1) (D) (S2)															Program steps	7
Operand	Type	Applicable elements														Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z		√
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√

Operand description

S1: Conversion source, hexadecimal data

D: destination operand.

S2: number of ASCII codes, 1 ≤ ***S2*** ≤ 256

Function description

When the power flow is valid, the hexadecimal data starting with ***S1*** element will be converted to ***S2*** ASCII codes, and the result is assigned to the elements starting with ***D***. When SM186 is OFF, the high/low byte of each ***D*** element will store two ASCII code data. When SM186 is ON, the low byte of each ***D*** element will store 1 ASCII code data.

Note

1. When ***S1*** and ***D*** use Kn addressing, Kn=4.
2. When ***S2*** is not within 1 ~ 256, the system will report operand error and will not execute the instruction, and ***D*** will not change.
3. If ***S1*** is a constant, ***S2*** will be regarded as 4 by default when ***S2*** ≥ 4, and the system will not report operand error.

Example

Source data: 0x9876

LD M0

ITA 16#9876 D20 6

When M0 is ON, execute ITA conversion, the data will be stored in two modes:

- If SM186=OFF, the execution result is: D20 = 0x3839, D21 = 0x3637.
- If SM186=ON, the execution result is D20 = 0x39, D21 = 0x38, D22 = 0x37, D23 = 0x36.

6.5.18 ATI: ASCII-Hexadecimal Integer Conversion Instruction

LAD: ATI (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry, borrow
IL: ATI (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: conversion source, ASCII code data 0x30 ≤ ***S1*** ≤ 0x39 or 0x41 ≤ ***S1*** ≤ 0x46 (when SM186 is OFF, the high byte and low byte of ***S1*** shall both be within this range)

D: destination operand.

S2: Number of ASCII codes; 1 ≤ ***S2*** ≤ 256

Function description

When the power flow is valid, the ***S2*** ASCII code data starting with ***S1*** element will be converted to hexadecimal data, and the result will be stored in the elements starting with ***D*** in every 4 bits. When SM186 is OFF, the high/low byte of each ***D*** element will store two ASCII code data. When SM186 is ON, the low byte of each ***D*** element will store 1 ASCII code data.

Note

1. When ***S1*** is not within 0x30 ~ 0x39 or 0x41 ~ 0x46, or ***S2*** is not within 1 ~ 256, the system will report operand error and will not execute the instruction, and ***D*** will not change.

3. If ***S1*** is a constant, ***S2*** will be regarded as 2 by default when SM186 is OFF and ***S2*** ≥ 2, or as when SM186 is ON and ***S2*** ≥ 1, and the system will not report operand error.

Example

LD M0

ATI D10 D30 4

Source data: D10 = 0x3938, D11 = 0x3736, D12 = 0x3534, D13 = 0x3332

When M0 is ON, the ATI conversion will be executed. According to the data storing mode, the results are as follows:

- If SM186 is OFF, the result is: D30 = 0x8967.
- If SM186 is ON, the result is: D30=0x8642.

6.6 Word Logic Operation

6.6.1 WAND: AND Word Instruction

LAD: WAND (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: WAND (S1) (S2) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S1: Source operand 1

S2: Source operand 2

D: destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic AND operation, and the result is assigned to ***D***.

Example

LD X0
WAND
D0 D1 D10

When X0 is ON, D0 2#1011011010010011 (46739) and D1 2#1001001100101110 (37678) will conduct logic AND operation, and the result 2#1001001000000010 (37378) is assigned to D10.

6.6.2 WOR: OR Word Instruction

LAD: WOR (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: WOR (S1) (S2) (D)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

***S1*:** Source operand 1

S2: Source operand 2

D: destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic OR operation, and the result is assigned to D.

Example

```
LD   X0
WOR  D0  D1
D10
```

When X0 is ON, D0 2#1011011010010011 (46739) and D1 2#1001001100101110 (37678) will conduct logic OR operation, and the result 2#1011011110111111 (47039) is assigned to D10.

.

6.6.3 WXOR: Exclusive-OR Word Instruction

LAD: WXOR (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: WXOR *(S1)* *(S2)* *(D)*	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

S1: Source operand 1

S2: Source operand 2

D: destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic exclusive OR operation, and the result is assigned to ***D***.

Example

```
LD   X0
WXOR D0  D1  D10
```

When X0 is ON, D0 2#1011011010010011 (46739) and D1 2#1001001100101110 (37678) will conduct logic exclusive OR operation, and the result 2#0010010110111101 (9661) is assigned to D10.

6.6.4 WINV: NOT Word Instruction

LAD: [WINV (S) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: WINV (*S*) (*D*)		**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√

Operand description

***S*:** Source operand

D: destination operand

Function description

When the power flow is valid, conduct logic NOT operation on ***S***, and assign the result to ***D***.

Example

```
LD    X0
WINV  D0  D1  D10
```

When X0 is ON, conduct logic NOT operation on D0 (46739), and assign the result 18796 to D10.

6.6.5 DWAND: AND Double Word Instruction

LAD: [DWAND (S1) (S2) (D)]		Applicable to	IVC2 IVC1
		Influenced flag bit	
IL: DWAND (*S1*) (*S1*) (*D*)		**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S1: Source operand 1

S2: Source operand 2

D: destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic AND operation, and the result is assigned to ***D***.

Example

```
LD    X0
DWAND D0  D2 D10
```

When X0 is ON, (D0, D1) 2#10110010101001101110011001010010 (2997282386) and (D2, D3) 2#00111010001110110011000100110011 (976957747) will conduct the logic AND operation, and the result 2#00110010001000100010000000010010 (841097234) is assigned to (D10, D11).

6.6.6 DWOR: OR Double Word Instruction

LAD: DWOR (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DWOR (*S1*) (*S2*) (*D*)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

***S1*:** Source operand 1

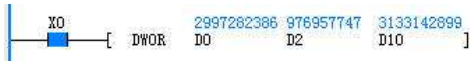
***S2*:** Source operand 2

***D*:** destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic OR operation, and the result is assigned to ***D***.

Example




```
LD   X0
DWOR D0 D2 D10
```

When X0 is ON, (D0, D1) 2#10110010101001101110011001010010 (2997282386) and (D2, D3) 2#00111010001110110011000100110011 (976957747) will conduct logic OR operation, and the result 2#10111010101111111111011101110011 (3133142899) is assigned to (D10, D11).

6.6.7 DWXOR: Exclusive-OR Double Word Instruction

LAD: DWXOR (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DWXOR (*S1*) (*S2*) (*D*)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

***S1*:** Source operand 1

***S2*:** Source operand 2

***D*:** destination operand

Function description

When the power flow is valid, ***S1*** and ***S2*** will conduct logic exclusive OR operation, and the result is assigned to ***D***.

Example

```
LD    X0
DWXOR D0 D2
D10
```

When X0 is ON, (D0, D1) 2#10110010101001101110011001010010 (2997282386) and (D2, D3) 2#00111010001110110011000100110011 (976957747) will conduct logic exclusive OR operation, and the result 2#10001000100111011101011101100001 (2292045665) is assigned to (D10, D11).

6.6.8 DWINV: NOT Double Word Instruction

LAD: ⊣⊢ ⊢[DWINV (S) (D)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: DWINV (S) (D)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√

Operand description

S: Source operand

D: destination operand

Function description

When the power flow is valid, logic NOT operation will be conducted on ***S***, and the result is assigned to ***D***.

Example

```
LD   X0
DWINV   D0   D10
```

When X0 is ON, logic NOT operation will be conducted on (D0, D1) 2#10110010101001101110011001010010 (2997282386), and the result 2#01001101010110010001100110101101 (1297684909) is assigned to (D10, D11).

6.7 Shift / Rotate Instruction

6.7.1 ROR: 16-Bit Circular Shift Right Instruction

LAD: ⊣⊢ ⊢[ROR (S1) (D) (S2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Carry flag SM181**
IL: ROR (S1) (D) (S2)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

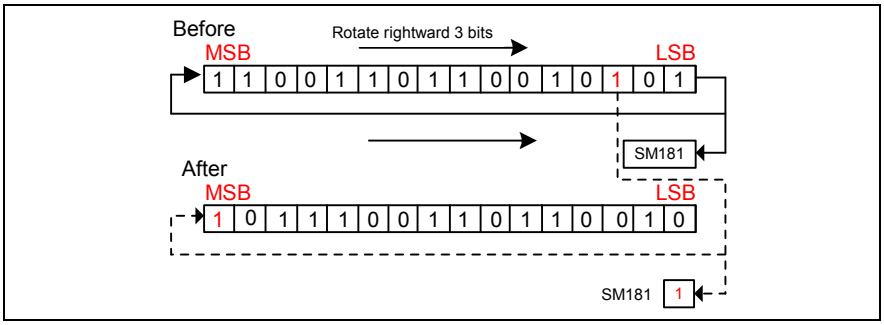
When the power flow is valid, the data of ***S1*** will rotate rightward for ***S2*** bits, and the result is assigned to ***D***. At the same time the highest bit of the ***S2*** bits will be stored into the carry flag (SM181).

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 4.

Example

```
LD   M0
ROR   D0   D10   3
```



When M0 is ON, D0 2#1100110110010101 (52629) rotates rightward for 3 bits, and the result 2#1011100110110010 (47538) is assigned to D10. The highest bit of the 3 bits is stored into the carry flag. SM181 is ON.

6.7.2 ROL: 16-Bit Circular Shift Left Instruction

LAD: ROL (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Carry
IL: ROL (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

When the power flow is valid, the data of ***S1*** will rotate leftward for ***S2*** bits, and the result is assigned to D. At the same time the lowest bit of the ***S2*** bits will be stored into the carry flag SM181.

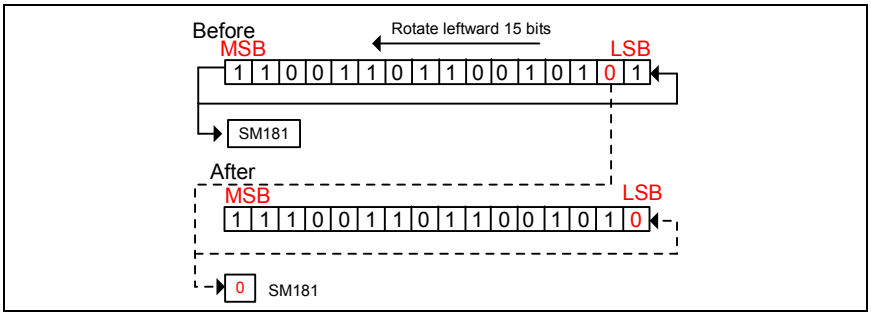
Note

1. ***S2*** ≥ 0.

2. When S1 uses Kn addressing, Kn must be equal to 4.

Example

```
LD   M0
ROL  D0 D10 15
```



When M0 is ON, D0 2#1100110110010101 (52629) rotates leftward for 15 bits, and the result 2#1110011011001010 (59082) is assigned to D10. The final bit will be stored in the carry flag bit. SM181 is OFF.

6.7.3 RCR: 16-Bit Carry Circular Shift Right Instruction

LAD: ⊣⊢ ⊢[RCR (S1) (D) (S2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Carry**
IL: RCR (*S1*) (*D*) (*S2*)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

When the power flow is valid, ***S1*** data and the carry flag (SM181) will together rotate rightward for ***S2*** bits, and the result is assigned to ***D***.

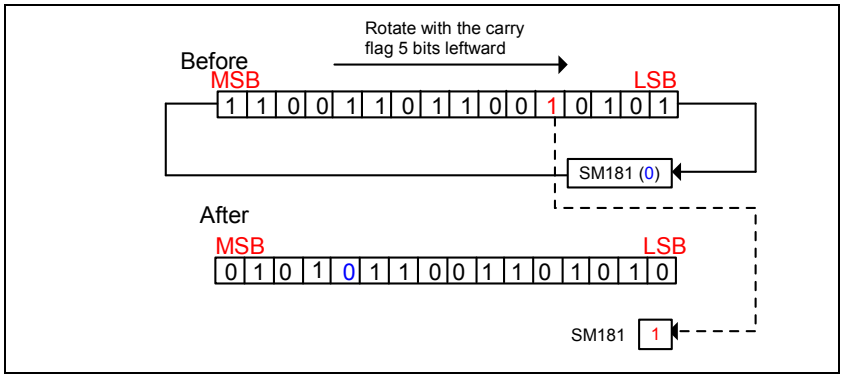
Note

1. ***S2*** ≥0.

2. When S1 uses Kn addressing, Kn must be equal to 4.

Example

```
LD   M0
RCR  D0 D10 5
```


Rotate with the carry flag 5 bits leftward
Before
MSB
LSB
1 1 0 0 1 1 0 1 1 0 0 1 0 1 0 1
SM181 (0)
After
MSB
LSB
0 1 0 1 0 1 1 0 0 1 1 0 1 0 1 0
SM181
1

When M0 is ON, D0 2#1100110110010101 (52629) and the carry SM181 (OFF) will rotate rightward for 5 bits, and the result 2#0101011001101100 (22124) is assigned to D10. SM181 = ON.

6.7.4 RCL: 16-Bit Carry Circular Shift Left Instruction

LAD: RCL (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Carry
IL: RCL (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

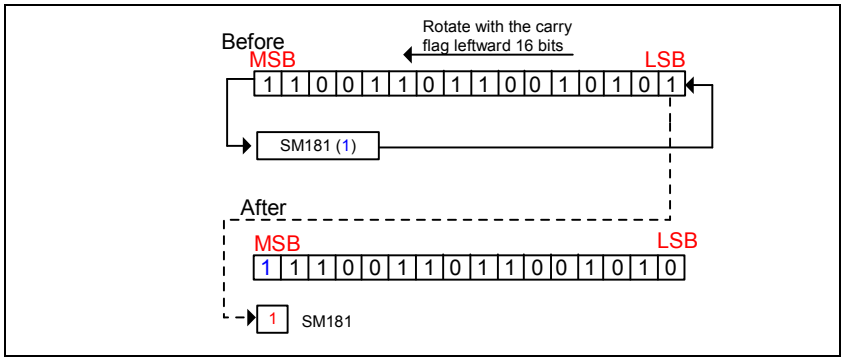
When the power flow is valid, ***S1*** data and the carry (SM181) will together rotate leftward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 4.

Example

```
LD   M0
RCL  D0 D10  16
```


Before
Rotate with the carry flag leftward 16 bits
MSB
LSB
1 1 0 0 1 1 0 1 1 0 0 1 0 1 0 1
SM181 (1)
After
MSB
LSB
1 1 1 0 0 1 1 0 1 1 0 0 1 0 1 0
1
SM181

When M0 is ON, D0 2#1100110110010101 (52629) and the carry SM181 (ON) will rotate leftward for 16-bits, and the result 2#1110011011001010 (59082) is assigned to D10. SM181=ON.

6.7.5 DROR: 32-Bit Circular Shift Right Instruction

LAD: DROR (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Carry
IL: DROR (S1) (D) (S2)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

When the power flow is valid, the data of ***S1*** will rotate rightward for ***S2*** bits, and the result is assigned to ***D***. At the same time the highest bit of the ***S2*** bits will be stored into the carry flag bit SM181.

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 8.

Example

```
LD   M0
DROR D0  D10  7
```

1. When M0 is ON, D0 (D1) 2#10110011100110001001110010101100 (3013123244) will rotate rightward for 7 bits, and the result 2#01011001011001110011000100111001 (1499935033) is assigned to (D10, D11). The final bit is stored into the carry flag bit. SM181 = OFF.
2. Please refer to the ROR instruction illustration.

6.7.6 DROL: 32-Bit Circular Shift Left Instruction

LAD: DROL (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Carry
IL: DROL (*S1*) (*D*) (*S2*)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

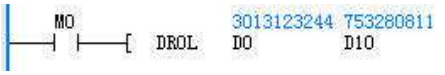
Function description

When the power flow is valid, the data of ***S1*** will rotate leftward for ***S2*** bits, and the result is assigned to D. At the same time the lowest bit of the ***S2*** bits will be stored into the carry flag bit SM181.

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 8.

Example




```
LD   M0
DROL D0  D10  30
```

1. When M0 is ON, (D0, D1) 2#10110011100110001001110010101100 (3013123244) will rotate leftward for 30 bits, and the result 2#00101100111001100010011100101011 (753280811) is assigned to (D10, D11). The final bit is stored into the carry flag bit. SM181=ON.
2. Please refer to the ROL instruction illustration.

6.7.7 DRCR: 32-Bit Carry Circular Shift Right Instruction

LAD: DRCR (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	Carry
IL: DRCR (*S1*) (*D*) (*S2*)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

Function description

When the power flow is valid, ***S1*** data and the carry SM181 will together rotate rightward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 8.

Example

```
LD   M0
DRCR D0
D10  11
```

1. When M0 is ON, (D0, D1) 2#10110011100110001001110010101100 (3013123244) and the carry SM181 (OFF) will rotate rightward for 11 bits, and the result 2#00101011000101100111001100010011 (722891539) is assigned to (D10, D11). SM181=ON.
2. Please refer to the RCR instruction illustration.

6.7.8 DRCL: 32-Bit Carry Circular Shift Left Instruction

LAD: ⊣⊢ ⊢[DRCL (S1) (D) (S2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Carry**
IL: DRCL (S1) (D) (S2)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

Function description

When the power flow is valid, the ***S1*** data and the carry SM181 will together rotate leftward for S2 bits, and the result is assigned to ***D***.

Note

1. S2 ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 8.

Example

1. When M0 is ON, (D0, D1) 2#10110011100110001001110010101100 (3013123244) and the carry SM181 (OFF) will rotate leftward for 25 bits, and the result 2#00101100010110011100110001001110 0 (1488165020) is assigned to (D10, D11). SM181 = ON.
2. Please refer to the RCL instruction illustration.

6.7.9 SHR: 16-Bit Shift Right Word Instruction

LAD: ⊣⊢ ⊢[SHR (S1) (D) (S2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: SHR (S1) (D) (S2)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

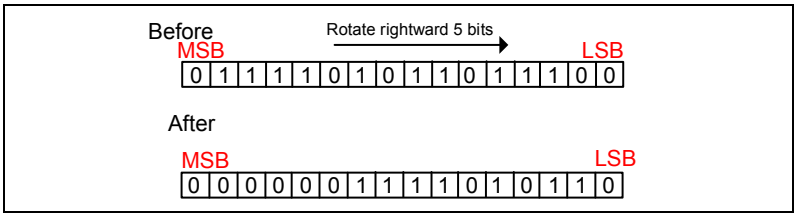
Function description

When the power flow is valid, the data of ***S1*** will shift rightward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥ 0.
2. When S1 uses Kn addressing, Kn must be equal to 4.

Example



When M0 is ON, D0 2#0111101011011100 (31452) shifts rightward for 5 bits, and the result 2#0000001111010110 (982) is assigned to D10.

6.7.10 SHL: 16-Bit Shift Left Instruction

LAD: SHL (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: SHL (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

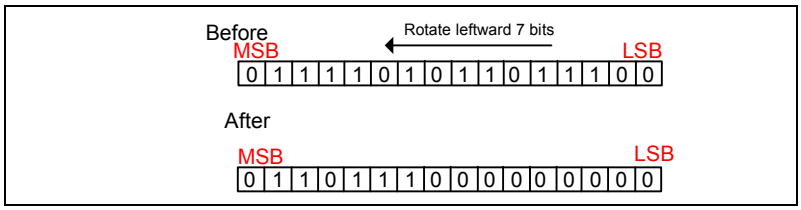
When the power flow is valid, the data of ***S1*** will shift leftward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥0.
2. When ***S1*** uses Kn addressing, Kn must be equal to 4.

Example

```
LD   M0
SHL  D0  D10  7
```



When M0 is ON, D0 2#0111101011011100 (31452) shifts leftward for 7 bits, and the result 2#0110111000000000 (28160) is assigned to D10.

6.7.11 DSHR: 32-Bit Shift Right Instruction

LAD: DSHR (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DSHR (S1) (D) (S2)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: Source operand 1

D: destination operand

S2: Source operand 2

Function description

When the power flow is valid, the data of ***S1*** will shift rightward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥0.
2. When ***S1*** uses Kn addressing, Kn must be equal to 8.

Example

```
LD   M0
DSHR D0 D10 10
```

1. When M0 is ON, (D0, D1) 2#01110011100110001001110010101100 (1939381420) shifts rightward for 10 bits, and the result 2#00000000000111001110011000100111 (1893927) is assigned to (D10, D11).
2. Please refer to the SHR instruction illustration.

6.7.12 DSHL: 32-Bit Shift Left Instruction

LAD: DSHL (S1) (D) (S2)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: DSHL (*S1*) (*D*) (*S2*)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	DWORD			KnY	KnM	KnS	KnLM		D		C		V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

Function description

When the power flow is valid, the data of ***S1*** will shift leftward for ***S2*** bits, and the result is assigned to ***D***.

Note

1. ***S2*** ≥ 0.
2. When ***S1*** uses Kn addressing, Kn must be equal to 8.

Example

```
LD   M0
DSHL D0 D10 15
```

1. When M0 is ON, (D0, D1) 2#01110011100110001001110010101100 (1939381420) shifts leftward for 15 bits, and the result 2#01001110010101100000000000000000 (1314258944) is assigned to (D10, D11).
2. Please refer to SHL instruction illustration.

6.7.13 SFTR: Shift Right Byte Instruction

LAD: SFTR (S1) (D) (S2) (S3)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: SFTR (*S1*) (*D*) (*S2*) (*S3*)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	BOOL		X	Y	M	S	LM	SM			C	T			√
D	BOOL			Y	M	S	LM				C	T			√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

S3: Source operand 3

Function description

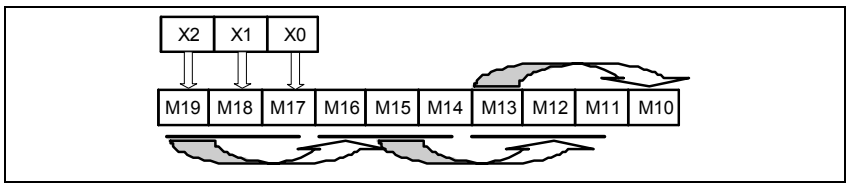
When the power flow is valid, ***S2*** elements starting with ***D*** will move rightward for ***S3*** units, and the ***S3*** elements at the rightmost side will be discarded. At the same time, the contents of ***S3*** elements starting with ***S1*** will be filled into the left end of the string.

Note

1. The elements with smaller SN are at the right, and the elements with larger SN are at the left.
2. ***S2*** ≥ 0.
3. ***S3*** ≥ 0.

Example

```
LD   M0
SFTR X0 M10 10 3
```



1. When M0 is ON, the contents of 10 elements starting with M10 will move rightward for 3 bits, and rightmost three elements M10 ~ M12 will be discarded. At the same time, the contents of the 3 elements starting with X0 will be filled into the left end of the string.

2. Before the execution: X0 = 1, X1 = 0, X2 = 1, M10 = 0, M11 = 1, M12 = 1, M13 = 0, M14 = 0, M15 = 1, M16 = 0, M17 = 0, M18 = 0, M19 = 1.

3. After the execution: the contents of X0 to X2 remain unchanged, M10 = 0, M11 = 0, M12 = 1, M13 = 0, M14 = 0, m15 = 0, m16 = 0, m17 = 1, m18 = 0, m19 = 1.

6.7.14 SFTL: Shift Left Byte Instruction

LAD: SFTL (S1) (D) (S2) (S3)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: SFTL (*S1*) (*D*) (*S2*) (*S3*)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	BOOL		X	Y	M	S	LM	SM			C	T			√
D	BOOL			Y	M	S	LM				C	T			√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

***S1*:** Source operand 1

***D*:** destination operand

***S2*:** Source operand 2

***S3*:** Source operand 3

Function description

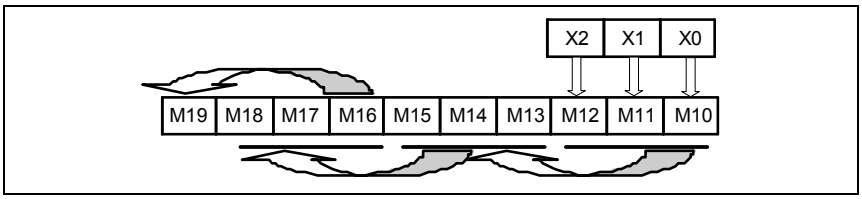
When the power flow is valid, ***S2*** elements starting with ***D*** will more leftward for ***S3*** units, and the ***S3*** elements at the leftmost side will be discarded. At the same time, the contents of ***S3*** elements starting with ***S1*** will be filled into the right end of the string.

Note

1. The elements with smaller SN are at the right, and the elements with larger SN are at the left.
2. ***S2*** ≥ 0.
3. ***S3*** ≥ 0.

Example

```
LD   M0
SFTL X0 M10 10 3
```



1. When M0 is ON, the contents of 10 elements starting with M10 will move leftward for 3 bits, and the leftmost elements M17 ~ M19 will be discarded. At the same time, the contents of the 3 elements starting with X0 will be filled into the right end of the string.

2. Before the execution: X0 = 1, X1 = 0, X2 = 1, M10 = 0, M11 = 1, M12 = 1, M13 = 0, M14 = 0, M15 = 1, M16 = 0, M17 = 0, M18 = 0, M19 = 1.

3. After the execution: the contents of X0 ~ X2 remain unchanged, M10 = 1, M11 = 0, M12 = 1, M13 = 0, M14 = 1, M15 = 1, M16 = 0, M17 = 0, M18 = 1, M19 = 0.

6.8 External Equipment Instruction

6.8.1 FROM: Read Word Form Special Module Buffer Register Instruction

LAD: [FROM (S1) (S2) (D) (S3)]	Applicable to	IVC2
	Influenced flag bit	
IL: FROM (*S1*) (*S2*) (*D*) (*S3*)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	INT	Constant													
D	INT								D				V		√
S3	INT	Constant													

Operand description

S1: SN of the special module to be read, or the target module.

Range: 0 ~ 7. If the target module does not exist, the system will report target module address invalid.

S2: The starting address in the BFM of the target module.

Range: 0 ~ 32767. If the BFM address is invalid, the system will report “BFM unit of accessed special module exceeds range”.

D: The D element where the data read from the target module will be stored.

S3: The number of consecutive buffer registers (single word) to be read.

Range: 1 ~ 32767. If the target register does not exist, the system will report “BFM unit of accessed special module exceeds range”.

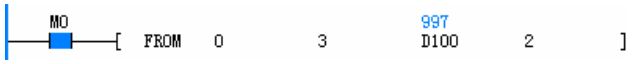
Function description

Read consecutively ***S3*** registers, starting with ***S2*** register, in the BFM of the target module (SN: ***S1***) and put them into the ***S3*** word elements starting with ***D***.

Note

The execution time of the FROM instruction is relatively long, and closely related to ***S3***.

Example




```
LD   M0
FROM 0 3 D100 2
```

When M0 is ON, read consecutively 2 registers, starting with register 3, in the BFM of the target module number 0, and put them into the word elements D100 and D101.

6.8.2 DFROM: Read Double Word Form Special Module Buffer Register Instruction

LAD: DFROM (S1) (S2) (D) (S3)	Applicable to	IVC2
	Influenced flag bit	
IL: DFROM (*S1*) (*S2*) (*D*) (*S3*)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	INT	Constant													
D	DINT								D				V		√
S3	INT	Constant													

Operand description

S1: SN of the special module to be read, or the target module.

Range: 0 ~ 7. If the target module does not exist, the system will report target module address invalid.

S2: The starting address in the BFM of the target module.

Range: 0 ~ 32767. If the BFM address is invalid, the system will report “BFM unit of accessed special module exceeds range”.

D: The D element where the data read from the target module will be stored.

S3: The number of consecutive buffer registers (double word) to be read.

Range: 1 ~ 32767. If the target register does not exist, the system will report “BFM unit of accessed special module exceeds range”

Function description

Read consecutively ***S3*** registers, starting with ***S2*** register, in the BFM of the target module (SN: ***S1***) and put them into the ***S3*** double-word elements starting with ***D***.

Note

The execution time of the DFROM instruction is relatively long, and closely related to ***S3***.

Example

When M0 is ON, read 1 double word from register 3, in the BFM of the target module number 0, and put it into the double word element (D200, D201).

6.8.3 TO: Write Word To Special Module Buffer Register Instruction

LAD: [TO (S1) (S2) (S3) (S4)]	**Applicable to**	**IVC2**
	Influenced flag bit	
IL: TO (*S1*) (*S2*) (*S3*) (*S4*)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	INT	Constant													
S3	INT								D				V		√
S4	INT	Constant													

Operand description

S1: The SN of the special module to be written, or the target module.

Range: 0 ~ 7. If the target module does not exist, the system will report “Using FROM/TO instruciton to access module not existing”.

S2: The starting register address in the BFM of the target module.

Range: 0 ~ 32767. If the BFM address is invalid, the system will report “BFM unit of accessed special module exceeds range”.

S3: The data to be written into the target module.

S4: The number of consecutive buffer registers (single word) to be written.

Range: 1 ~ 32767. If the target register does not exist, the system will report “BFM unit of accessed special module exceeds range”.

Function description

1. Write data from consecutive ***S4*** registers starting with ***S3*** to the consecutive ***S4*** buffer registers starting with ***S2*** in the BFM of the target module (SN: ***S1***).
2. If ***S3*** is a constant, write it consecutively into the ***S4*** word elements starting with ***S2*** in the BFM of special module ***S1***.

Note

The execution time of the TO instruction is relatively long, and closely related to ***S4***.

Example

When PLC runs, write 1000 respectively to buffer registers 8 and 9 in the BFM of target module number 0.

6.8.4 DTO: Write Double Word To Special Module Buffer Register Instruction

LAD: DTO (S1) (S2) (S3) (S4)	Applicable to	IVC2
	Influenced flag bit	
IL: DTO (S1) (S2) (S3) (S4)	Program steps	10

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	INT	Constant														
S3	DINT								D				V			√
S4	INT	Constant														

Operand description

S1: The SN of the special module to be written, or the target module.

Range: 0 ~ 7. If the target module does not exist, the system will report "Using FROM/TO instruciton to access module not existing".

S2: The starting register address in the BFM of the target module.

Range: 0 ~ 32767. If the BFM address is invalid, the system will "BFM unit of accessed special module exceeds range".

S3: The data to be written into the target module.

S4: The number of consecutive buffer registers (double word) to be written.

Range: 1 ~ 32767. If the target register does not exist, the system will report "BFM unit of accessed special module exceeds range".

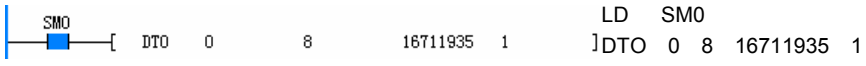
Function description

1. Write data from consecutive ***S4*** registers starting with ***S3*** to the consecutive ***S4*** buffer registers starting with ***S2*** in the BFM of the target module (SN: ***S1***).
2. If ***S3*** is a constant, write it consecutively into the ***S4*** double-word elements starting with ***S2*** in the BFM of special module ***S1***.

Note

The execution time of the DTO instruction is relatively long, and closely related to ***S4***.

Example



When PLC runs, write a double word data 16711935 to buffer registers 8 and 9 (which forms a double-word element) in the BFM of target module number 0.

6.8.5 VRRD: Read Analog Potentiometer Value Instruction

LAD: VRRD (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: VRRD (S) (D)	Program steps	5

Operand	Type	Applicable elements														Offset addressing
S	WORD	Constant														
D	WORD								D				V			√

Operand description

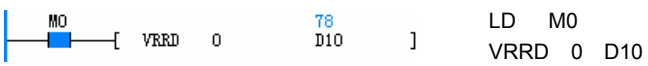
S: The specified potentiometer SN. Range: 0 ~ 255. If ***S*** is set outside this range, the system will report operand error.

D: The element where the read analog potentiometer value will be stored. Range: 0 ~ 255.

Function description

Read the value of the specified analog potentiometer and store it into the specified element.

Example



When M0 is ON, read the value of analog potentiometer 0 and put the reading into D10.

6.8.6 REFF: Set Input Filtering Constant Instruction

LAD: [REFF (S)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: REFF (S)	**Program steps**	**3**

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: Input filtering constant

- IVC2

Range: 0 ~ 64ms. Any setting bigger than 64 will be regarded as 64.

- IVC1

Range: 0, 8, 16, 32, 64. Any setting between any two values will be regarded as the smaller value. For example, a setting between 8 and 16 will be regarded as 8. Any setting bigger than 64 will be regarded as 64.

Function description

Set the input filtering constant of X0 ~ X17.

Note

The input filtering constant is valid only for non-high-speed input points.

Example

```
LD   M0
REFF 30
```

When X10 is ON, set the input filtering constant to 30ms.

6.8.7 REF: Instant Refresh I/O Instruction

LAD: [REF (D) (S)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: REF (D) (S)	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
D	BOOL		X	Y											
S	INT	Constant													

Operand description

D: the starting X or Y element to be refreshed. The specified starting element address should always be a multiple of 8 (in octal system). For example, X0, X10, X20… or Y0, Y10, Y20….

S: the number of inputs and outputs to be refreshed. It should always be a multiple of 8, for example, 8, 16, ..., 256, and so on.

Function description

Generally, the PLC will not refresh its inputs or outputs before the user program ends. However, if you want to refresh the inputs or outputs when the user program is still running, you can use this instruction.

Note

Generally, the REF instruction is used to refresh I/O immediately between the FOR-NEXT instruction and the CJ instruction.

You can also use the REF instruction to obtain the latest input and output the operation result without delay during the execution of the interrupts with I/Os.

To refresh a relay output, you need to consider the response time.

Example

```
LD   M0
REF  Y0  8
```

When M0 is ON, the stats at Y0 ~ Y7 will be output immediately regardless of the scan cycle.

6.8.8 EROMWR: EEPROM Write Instruction

LAD: ┤├──[EROMWR (S1) (S2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: EROMWR (S1) (S2)	**Program steps**	**6**

Operand	Type	Applicable elements													Offset addressing
S1	WORD								D						
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: starting address of the elements to be stored. Range: D6000 ~ D6999

S2: number of the elements to be stored. ***S2***<16

S1 + ***S2*** < D7000

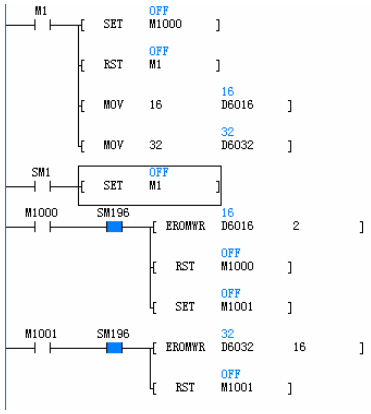
Function description

1. Partial PLC data are battery backed. However, during the calculation, you can save the intermediate data into EEPROM with the EROMWR instruction.
2. This instruction is executed upon the rising edge.
3. Two EROMWR instructions cannot be executed at the same time. When SM196, the EEPROM write OK flag, is ON, it indicates that EEPROM is okay for write operation. When SM196 is OFF, it indicates that an EROMWR instruction is being executed.

Note

An EROMWR instruction will make the scan cycle 2 ~ 5ms longer. It is recommended to set the ***S1*** to 6000 plus an integer multiple of 16, like D6000, D6016 and D6032.

Example




```
LD     M1
SET    M1000
RST    M1
MOV 16 D6016
MOV 32 D6032
LD     SM1
SET    M1
LD     M1000
AND    SM196
EROMWR D6016  2
RST    M1000
SET    M1001
LD     M1001
AND SM196
EROMWR D6032  16
RST    M1001
```

In the preceding example, two sets of D elements are stored in the EEPROM:

1. SM1 and M1 makes M1000 generate a rising edge during the second scan cycle and triggers the execution of the first EROMWR instruction.
2. M1001 and SM196 makes the second rising edge, triggering the execution of the second EROMWR instruction.

6.9 Real-Time Clock Instruction

6.9.1 TRD: Read Real-Time Clock Instruction

LAD: [TRD (D)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: TRD (*D*)	**Program steps**	**3**

Operand	Type	Applicable elements													Offset addressing
D	WORD								D				V		√

Operand description

D: the starting storage element for the system time, which occupies the 7 consecutive elements starting with ***D***

Function description

Read the system time and store the value in the storage elements designated by D.

Note

The TRD instruction will fail upon system clock setting error.

Example

```
LD   M0
TRD  D10
```

When M0 is ON, send the system time to the 7 elements starting with D10.

The execution result of the instruction is as follows:

	Element	Item	Clock data		Element	Item
Special data register for real time clock	SD100	Year	2000 to 2099	——→	D10	Year
	SD101	Month	1 to 12	——→	D11	Month
	SD102	Day	1 to 31	——→	D12	Day
	SD103	Hour	0 to 23	——→	D13	Hour
	SD104	Minute	0 to 59	——→	D14	Minute
	SD105	Second	0 to 59	——→	D15	Second
	SD106	Week	0 to 6	——→	D16	Week

6.9.2 TWR: Write Real-Time Clock Instruction

LAD: ⊣⊢ ⊢[TWR (S)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: TWR (S)	**Program steps**	**3**

Operand	Type	Applicable elements													Offset addressing
S	WORD								D				V		√

Operand description

S: the element where the system time is to be written

	Element	Item	Clock data		Element	Item
Data for clock setting	D10	Year	2000 to 2099	——→	SD100	Year
	D11	Month	1 to 12	——→	SD101	Month
	D12	Day	1 to 31	——→	SD102	Day
	D13	Hour	0 to 23	——→	SD103	Hour
	D14	Minute	0 to 59	——→	SD104	Minute
	D15	Second	0 to 59	——→	SD105	Second
	D16	Week	0 to 6	——→	SD106	Week

Function description

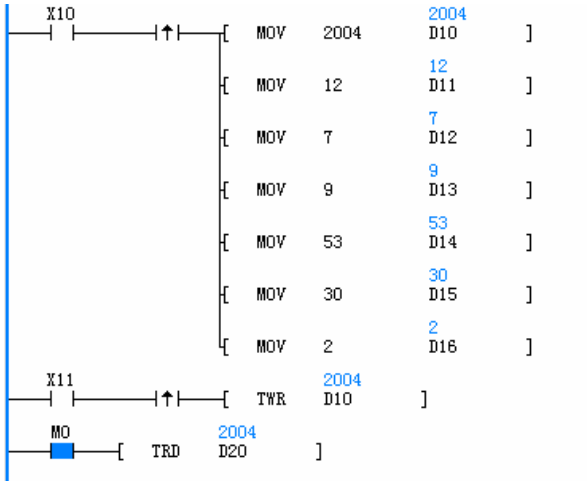
When the system time is different from the real time, you can use the TWR instruction to correct the system time.

Note

1. The time must use the solar calendar, or the instruction will not be executed.
2. It is recommended to use the edge to trigger the execution of the instruction.

Example

Changing the system time with the TWR instruction is shown in the following figure:




```
LD    X10
EU
MOV   2004   D10
MOV   12     D11
MOV   7      D12
MOV   9      D13
MOV   53     D14
MOV   30     D15
MOV   2      D16
LD    X11
EU
TWR   D10
LD    M0
TRD   D20
```

1. Upon the rising edge of X10, write the time setting into the 7 consecutive units starting with D10 (D10 ~ D16).
2. Upon the rising edge of X11, write the values of elements D10 ~ D16 into the system time.
3. When M0 is On, read the system time and save it into D20 ~ D26.

6.9.3 TADD: Add Clock Instruction

LAD: TADD (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, carry
IL: TADD (*S1*) (*S2*) (*D*)	Program steps	7

Operand	Type	Applicable elements												Offset addressing
S1	WORD								D	SD			V	√
S2	WORD								D	SD			V	√
D	WORD								D				V	√

Operand description

S1: clock data1. The 3 storage elements designated by ***S1*** are used to store the time data. If the data is not compliant with the time format, the system will report “Illegal instruction operand value”.

S2: clock data2. The 3 storage elements designated by ***S2*** are used to store another time data. If the data is not compliant with the time format, the system will report “Illegal instruction operand value”.

D: time result storage unit. The result of the time adding operation is stored in the 3 storage elements designated by ***D***. The result will affect the carry flag SM181 and the zero flag SM180.

Function description

Add two time-format data. The operation rules follow the time format.

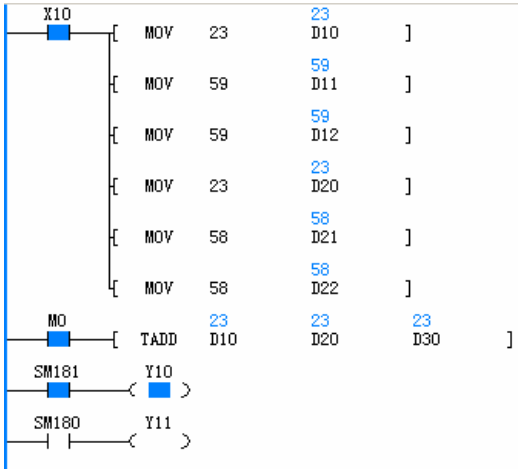
Note

The time data for the operation must meet the time setting range requirements.

- Hour: 0 ~ 23
- Minute: 0 ~ 59
- Second: 0 ~ 59

Example

S1		+	*S2*		=	*D*	
D10	23 (hour)		D20	23 (hour)		D30	23 (hour)
D11	59 (minute)		D21	58 (minute)		D31	58 (minute)
D12	59 (second)		D22	58 (second)		D32	57 (second)




```
LD    X10
MOV   23  D10
MOV   59  D11
MOV   59  D12
MOV   23  D20
MOV   58  D21
MOV   58  D22
LD    M0
TADD  D0  D20  D30
LD    SM181
OUT   Y10
LD    SM180
OUT   Y11
```

1. When X10 is ON, send the time data to the 3 storage elements starting with D10 (D10 ~ D12) and the 3 storage elements starting with D20 (D20 ~ D22).
2. When M0 is ON, add the data in D10 ~ D12 and the data in D20 ~ D22, and store the result in the 3 storage elements starting with D30.
3. The carry flag (SM181) will be set to ON, and the zero flag (SM180) will be set to OFF.

6.9.4 TSUB: Subtract Clock Instruction

LAD: TSUB (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	Zero, borrow
IL: TSUB (*S1*) (*S2*) (*D*)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD								D	SD			V		√
S2	WORD								D	SD			V		√
D	WORD								D				V		√

Operand description

S1: clock data1. The 3 storage elements designated by ***S1*** are used to store the time data. If the data is not compliant with the time format, the system will report “Illegal instruction operand value”.

S2: clock data2. The 3 storage elements designated by ***S2*** are used to store another time data. If the data is not compliant with the time format, the system will report “Illegal instruction operand value”.

D: time result storage unit. The result of the time subtracting operation is stored in the 3 storage elements designated by ***D***. The result will affect the carry flag SM181 and the zero flag SM180.

Function description

Conduct subtract operation on the time format data, with the operation rules following the time format.

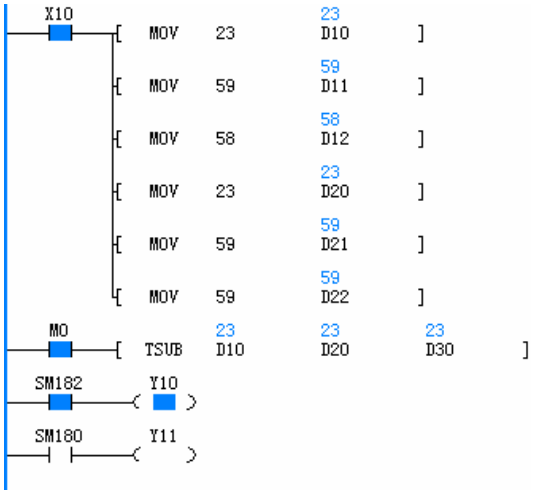
Note

The time data for the operation must meet the time setting range requirements.

- Hour: 0 ~ 23
- Minute: 0 ~ 59
- Second: 0 ~ 59

Example

S1		-	S2		=	D	
D10	23 (hour)		D20	23 (hour)		D30	23 (hour)
D11	59 (minute)		D21	59 (minute)		D31	59 (minute)
D12	58 (second)		D22	59 (second)		D32	59 (second)




```
LD   X10
MOV  23  D10
MOV  59  D11
MOV  58  D12
MOV  23  D20
MOV  59  D21
MOV  59  D22
LD   M0
TSUB D10  D20  D30
LD   SM182
OUT  Y10
LD   SM180
OUT  Y11
```

1. When X10 is ON, send the time data to the 3 storage elements starting with D10 (D10 ~ D12) and the 3 storage elements starting with D20 (D20 ~ D22).
2. When M0 is ON, subtract the data in (D20 ~ D22) from the data in (D10 ~ D12), and store the result in the 3 storage elements starting with D30.
3. The carry flag (SM182) will be set to ON, and the zero flag (SM180) will be set to OFF.

6.9.5 HOUR: Timing List Instruction

LAD: HOUR (S) (D1) (D2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: HOUR (*S*) (*D1*) (*D2*)	Program steps	8

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D1	INT								D				V		√
D2	BOOL			Y	M	S	LM								

Operand description

S: the hour comparison data. Range: 0 ~ 32767.

D1: time storage starting element. ***D1***: hour. ***D1***+1: second.

D2: alarm output address. When ***D1*** ≥ ***S***, the alarm point changes to ON, and generates output.

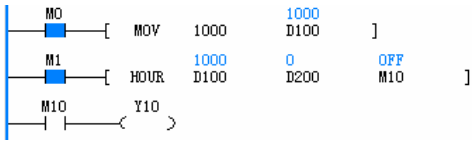
Function description

Make judgment on the time when the input contact is ON (unit: hour).

Note

1. To sustain the current data after power off, set ***D1*** within the element Saving Range (see *2.2.1 System Block*). Otherwise, the current data will be cleared upon PLC power off or when PLC changes from RUN to STOP.
2. The timing still continues even when the alarm output ***D2*** is ON.
3. The hour data in this instruction is a 16-bit integer. It will restart from 0 after 32767.

Example




```
LD    M0
MOV   1000  D100
LD    M1
HOUR  D100  D200  M10
LD    M10
OUT   Y10
```

1. When M0 is ON, set the comparison data of HOUR instruction.
2. When M1 is ON, accumulate the time for the input contact.
3. M10 will be ON when the accumulated time ≥ 1000.

6.9.6 DCMP: Compare Date (=, <, >, <>, >=, <=) Instruction

LAD:	Applicable to	IVC2 IVC1
DCMP= (S1) (S2) (D) DCMP< (S1) (S2) (D) DCMP> (S1) (S2) (D) DCMP<> (S1) (S2) (D) DCMP>= (S1) (S2) (D) DCMP<= (S1) (S2) (D)	Influenced flag bit	
IL: **DCMP= (S1) (S2) (D)** **DCMP< (S1) (S2) (D)** **DCMP> (S1) (S2) (D)** **DCMP<> (S1) (S2) (D)** **DCMP>= (S1) (S2) (D)** **DCMP<= (S1) (S2) (D)**	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT								D	SD			V		√
S2	INT								D	SD			V		√
D	BOOL			Y	M	S	LM				C	T			

Operand description

S1: starting word element for date comparison data 1, which occupies the 3 word elements following ***S1***. The data must comply with the solar calendar format, or the system will report operand error.

S2: starting word element for date comparison data 2, which occupies the 3 word elements following ***S2***. The data must comply with the solar calendar format, or the system will report operand error.

D: Comparison status output. When the data meet the comparison condition, ***D*** is set ON; otherwise, it is set OFF.

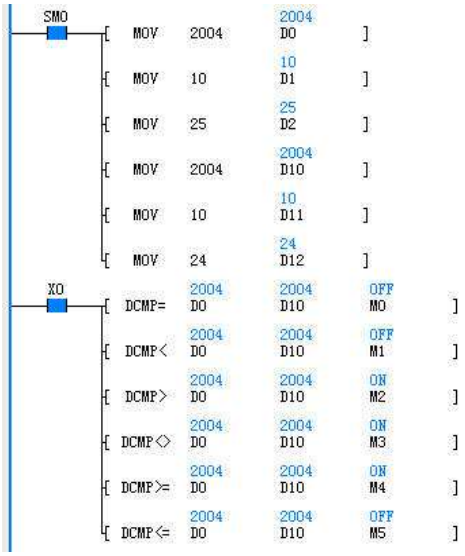
Function description

Conduct BIN comparison on the date data stored in the elements starting with ***S1*** and ***S2***, and assign the comparison result to ***D***.

Note

The date data stored in the elements starting with ***S1*** and ***S2*** must comply with the solar calendar format, or the system will report operand error. For example, “2004, 9, 31” and “2003, 2, 29” are both illegal.

Example




```
LD      SM0
MOV 2004 D0
MOV 10   D1
MOV 25   D2
MOV 2004 D10
MOV 10   D11
MOV 24   D12
LD      X0
DCMP= D0 D10 M0
DCMP< D0 D10 M1
DCMP> D0 D10 M2
DCMP<> D0 D10 M3
DCMP>= D0 D10 M4
DCMP<= D0 D10 M5
```

Conduct BIN comparison on the date data stored in the elements starting with D0 and D10, and assign the comparison result to M0.

6.9.7 TCMP: Compare Time (=, <, >, <>, >=, <=) Instruction

LAD:	Applicable to	IVC2 IVC1
TCMP= (S1) (S2) (D) TCMP< (S1) (S2) (D) TCMP> (S1) (S2) (D) TCMP<> (S1) (S2) (D) TCMP>= (S1) (S2) (D) TCMP<= (S1) (S2) (D)	**Influenced flag bit**	
IL: **TCMP= (*S1*) (*S2*) (*D*)** **TCMP< (*S1*) (*S2*) (*D*)** **TCMP> (*S1*) (*S2*) (*D*)** **TCMP<> (*S1*) (*S2*) (*D*)** **TCMP>= (*S1*) (*S2*) (*D*)** **TCMP<= (*S1*) (*S2*) (*D*)**	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	INT								D	SD			V		√
S2	INT								D	SD			V		√
D	BOOL			Y	M	S	LM				C	T			

Operand description

S1: starting word element for date comparison data 1, which occupies the 3 word elements following ***S1***. The data must comply with the 24-hour time format, or the system will report operand error.

S2: starting word element for date comparison data 2, which occupies the 3 word elements following ***S2***. The data must comply with the 24-hour time format, or the system will report operand error.

D: comparison status output. When the data meet the comparison condition, ***D*** is set ON; otherwise, it is set OFF.

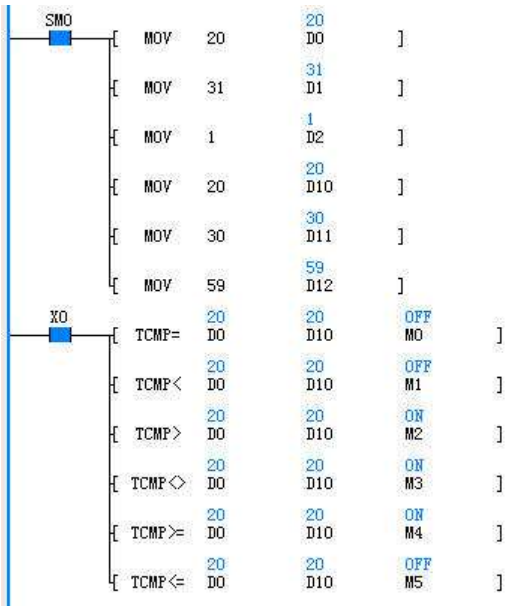
Function description

Conduct BIN comparison on the time data stored in the elements starting with ***S1*** and ***S2***, and assign the comparison result to ***D***.

Note

The time data stored in the elements starting with ***S1*** and ***S2*** must comply with the 24-hour system, or the system will report operand error. For example, “24, 10, 31” and “13, 59, 60” are both illegal.

Example




```
LD      SM0
MOV   20   D0
MOV   31   D1
MOV   1    D2
MOV   20   D10
MOV   30   D11
MOV   59   D12
LD      X0
TCMP=   D0   D10   M0
TCMP<   D0   D10   M1
TCMP>   D0   D10   M2
TCMP<>  D0   D10   M3
TCMP>=  D0   D10   M4
TCMP<=  D0   D10   M5
```

Conduct BIN comparison on the time data stored in the elements starting with D0 and D10, and assign the comparison result to M0.

6.10 High-speed I/O Instruction

6.10.1 HCNT: High-speed Counter Drive Instruction

LAD: HCNT (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: HCNT (D) (S)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
D	DINT										C				
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√

Operand description

D: Counter SN. Range: C236 ~ C255.

S: Comparison constant, a signed 32-bit data. Range: -2147483648 ~ 2147483647.

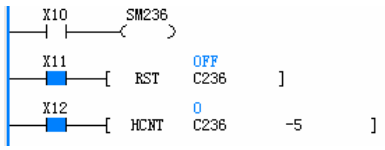
Function description

Drive the specified hardware high speed counter. All high speed counter must be driven to perform high speed counting. Meanwhile, the NO contact action of the counter will be judged based on the ***S*** value.

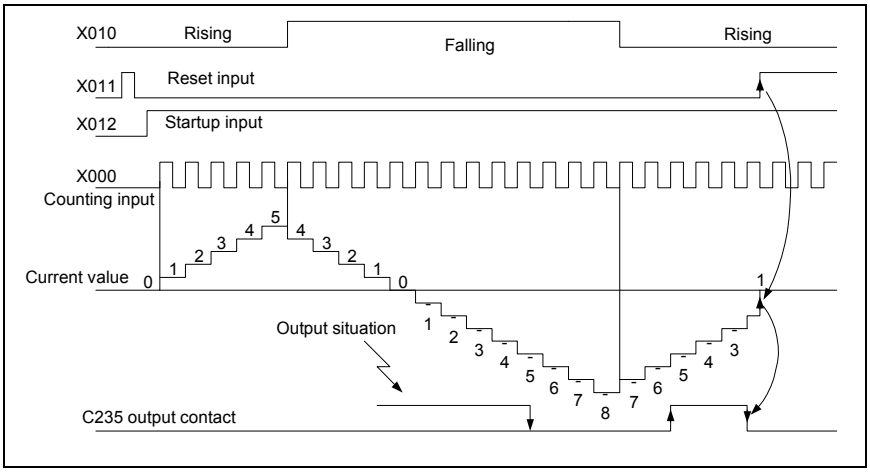
Note

The HCNT instruction, SPD instruction, external input interrupt and pulse capture may have contradictory hardware demands. Pay attention to the preconditions of all system high speed I/Os, and refer to the instruction description in actual practice.

Example




```
LD      X10
OUT     SM236
LD      X11
RST     C236
LD      X12
HCNT    C236   -5
```



1. When X12 changes from OFF to ON, the hardware counter C236 will be initialized. X0 is the pulse input point for C236, which counts the pulse input through X0. When X12 is OFF, X0 is a common input point, and C236 cannot count the external pulse of X0.

2. Contact actions: when the current value of the counter C236 increases from -6 to -5, the contact of C236 will be set. When the counter C236 decreases from -5 to -6, the contact of C236 will be reset.

3. When X11 is ON, the RST instruction will be executed, C236 will be cleared, and the C236 contact will be disconnected.

4. When PLC is powered off, the data of the high-speed counter and the contact status is set by the user in the system block through the AutoStation software.

6.10.2 DHSCS: High-speed Counting Compare Set Instruction

LAD: ┤├──[DHSCS (S1) (S2) (D)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: DHSCS (*S1*) (*S2*) (*D*)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
		Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		
S1	DINT										C				√
S2	DINT										C				
D	BOOL			Y	M	S									

Operand description

S1: a 32-bit DINT data, the one with which the high speed counter will compare. Range: -2147483648 ~ 2147483647.

S2: high speed counter. Range: C236 ~ C255.

D: target bit element, including Y, M and ***S*** elements. They will be set or output immediately regardless of the scan cycle.

Function description

1. A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON. When high-speed counter counts to ***S1*** in the DHSCS instruction, the bit element ***D*** will be set immediately, or, in the case of a Y element, the Y element will output immediately.

2. This instruction can be used when you want to set (and output, for Y elements) a certain bit element by comparing the counter value with a preset value.

Note

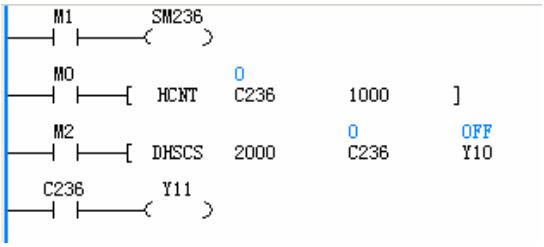
1. The DHSCS instruction must work together with the HCNT instruction, because DHSCS is only applicable to the high speed counters that is driven by HCNT.

2. The DHSCS instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.

3. DHSCS (DHSCI, DHSCR, DHSZ, DHSP, DHST) can be used repeatedly. However, at most the first six such instructions can be driven at the same time.

4. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O.*

Example




```
LD      M1
OUT     SM236
LD      M0
HCNT    C236   1000
LD      M2
DHSCS   2000   C236   Y10
LD      C236
OUT     Y11
```

1. When M1 is ON, C236 will count in the interrupt mode when X0 changes from OFF to ON (see *Chapter 8 Using High Speed I/O* for the description of the X0 input frequency). When C236 changes from 999 to 1000, the C236 contact will be set. When C236 changes from 1001 to 1000, the C236 contact will be reset. When the C236 contact drives Y11, the execution of Y11 is determined by the user program scan cycle.

2. When M2 is ON, and the DHSCS instruction meets the requirements stated in the preceding “Note”, Y10 will output immediately if C236 reaches 2000, regardless of the the scan cycle.

3. When M0 is ON, SM236 is driven, and the C236 counter counts down. When M0 is OFF, SM236 is not driven, and the C236 counter counts up.

6.10.3 DHSCI: High-speed Counting Compare Interrupt Trigger Instruction

LAD: DHSCI (S1) (S2) (S3)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DHSCI (S1) (S2) (S3)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT										C				
S3	WORD	Constant													

Operand description

S1: a 32-bit DINT data, the one with which the high speed counter will compare. Range: -2147483648 ~ 2147483647.

S2: high speed counter. Range: C236 ~ C255.

S3: interrupt SN. Range: 20 ~ 25.

Function description

A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON. When the counter counts to ***S1***, the ***S3*** interrupt will start. You can write the interrupt according to your actual needs.

Note

1. The DHSCI instruction must work together with the HCNT instruction, because DHSCI is only applicable to the high speed counters that is driven by HCNT.

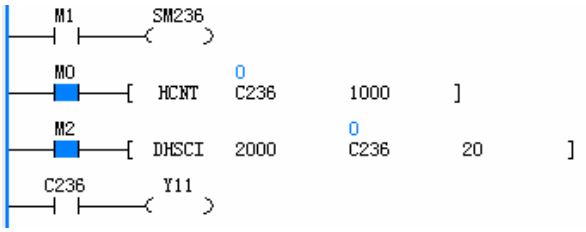
2. The DHSCI instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.

3. DHSCI (DHSCS, DHSCR, DHSZ, DHSP, DHST) can be used repeatedly. However, at most the first six such instructions can be driven at the same time.

4. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O*.

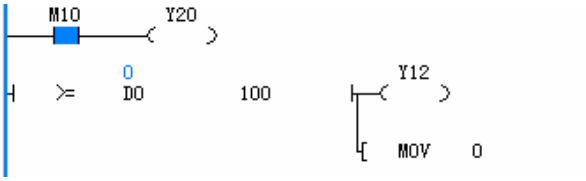
Example

Main user program:




```
LD      M1
OUT     SM236
LD      M0
DHSCI   2000   C236   20
LD      C236
OUT     Y11
```

Interrupt No.20:




```
LD      M10
OUT     Y20
LD>=    D0   100
OUT     Y12
MOV     0   D0
```

1. When M1 is ON, C236 will count in the interrupt mode when X0 changes from OFF to ON (see *Chapter 8 Using High Speed I/O* for the description of the X0 input frequency). When C236 changes from 999 to 1000, the C236 contact will be set. When C236 changes from 1001 to 1000, the C236 contact will be reset. When C236 contact drives Y11, the execution of Y11 will be determined by the user program scan cycle.

2. When M2 is ON, and the DHSCI instruction meets the requirements stated in the preceding “Note”, interrupt No.20 will be executed immediately when C236 reaches 2000, regardless of the the scan cycle.

3. When M0 is ON, SM236 is driven, and the C236 counter counts down. When M0 is OFF, SM236 is not driven, and the C236 counter counts up.

4. With pulse input, interrupt No.20 will be executed when C236 reaches 2000, and Y20 will be driven when M10 is ON. But, the output of Y20 is related to the scan cycle. Meanwhile, Y12 will be driven and D0 will be cleared when D0 is detected to be larger than 100.

6.10.4 DHSCR: High-speed Counting Compare Reset Instruction

LAD: DHSCR (S1) (S2) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: DHSCR (*S1*) (*S2*) (*D*)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT										C				
D	BOOL			Y	M	S					C				

Operand description

S1: a 32-bit DINT data, the one with which the high speed counter will compare. Range: -2147483648 ~ 2147483647.

S2: high speed counter. Range: C236 ~ C255.

D: target bit element. The action on Y, M, ***S*** or C will be valid immediately regardless of the scan cycle. If ***D*** is a C element, it must be ***S2***.

Function description

A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON. When the counter counts to ***S1***, the ***D*** element will be reset (and output, for Y elements) immediately. You can use this instruction when you want to reset (and output, for Y elements) a certain bit element by comparing the counter value with a preset value.

Note

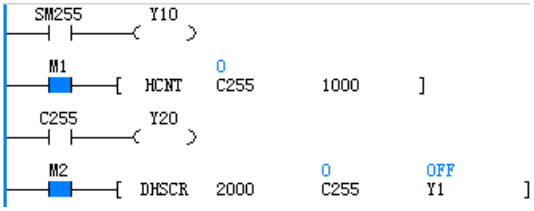
1. The DHSCR instruction must work together with the HCNT instruction, because DHSCR is only applicable to the high speed counters that is driven by HCNT.

2. The DHSCR instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.

3. DHSCR (DHSCI, DHSCS, DHSZ, DHSP, DHST) can be used repeatedly. However, at most the first six such instructions can be driven at the same time.

4. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O.*

Example




```
LD    SM255
OUT   Y10
LD    M1
HCNT  C255  1000
LD    C255
OUT   Y20
LD    M2
DHSCR 2000  C255  Y1
```

1. When M1 and X7 are both ON, C255 counts the phase difference of X3 and X4 in the interrupt mode. When C255 changes from 999 to 1000, C255 contact will be set, and reset when C255 changes from 1001 to 1000. When C255 contact drives Y20, the execution of Y20 will be determined by the user program scan cycle.

2. When M2 is ON, and the DHSCR instruction meets the requirements stated in the preceding “Note”, Y1 will be output immediately when C255 reaches 2000, regardless of the the scan cycle.

3. When the X3 pulse input is ahead of X4, SM255 is ON. When the X4 pulse input is ahead of X3, SM255 is OFF.

4. When X7, the startup signal of C255, is OFF, C255 will not count.

5. When M1 and X7 are all ON, if X5 is ON, C255 will be cleared, and C255 auxiliary contact will be reset.

6.10.5 DHSZ: High-speed Counting Zone Compare Instruction

LAD: DHSZ (S1) (S2) (S3) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: DHSZ (*S1*) (*S2*) (*S3*) (*D*)	**Program steps**	**13**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S3	DINT										C				
D	BOOL			Y	M	S									

Operand description

S1: a 32-bit DINT data, one of the two numbers with which the high speed counter will compare. Range: -2147483648 ~ 2147483647.

S2: a 32-bit DINT data, one of the two numbers with which the high speed counter will compare. Range: -2147483648 ~ 2147483647.

S3: high speed counter. Range: C236 ~ C255.

D: target bit element. The action on Y, M or ***S*** will be valid immediately regardless of the scan cycle.

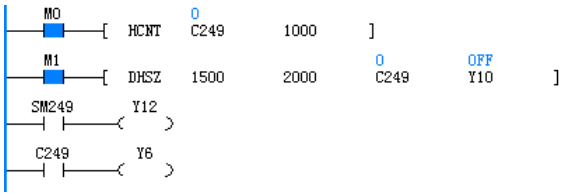
Function description

1. A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON.
2. When the counter value is smaller than ***S1***, the ***D*** element will be set. In addition, the ***D***+1 and ***D***+2 elements will be reset.
3. When the counter value is ≥S1 and ≤S2, the ***D*** and ***D***+2 elements will be reset, while the ***D***+1 element will be set.
4. When the counter value is bigger than ***S2***, the ***D*** and ***D***+1 elements will be reset, while ***D***+2 element will be set.
5. If D is a Y element, it will be output immediately regardless of the scan cycle.

Note

1. The DHSZ instruction must work together with the HCNT instruction, because DHSZ is only applicable to the high speed counters that is driven by HCNT.
2. The DHSZ instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.
3. DHSZ (DHSCI, DHSCS, DHSCR, DHSP, DHST) can be used repeatedly. However, at most the first six such instructions can be driven at the same time.
4. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O*.

Example




```
LD    M0
HCNT  C249  1000
LD    M1
DHSZ  1500  2000  C249  Y10
LD    SM249
OUT   Y12
LD    C249
OUT   Y6
```

1. When M0 and X6 are both ON, C249 will count up when X0 changes from OFF to ON, or count down when X1 changes from OFF to ON. When C249 changes from 999 to 1000, the C249 contact will be set; when C249 changes from 1001 to 1000, the C249 contact will be reset. When C249 contact drives Y6, the execution of Y6 will be determined by the user program scan cycle.
2. When M1 is ON, the DHSZ instruction meets the requirements stated in the preceding “Note”, the states of elements Y10 ~ Y12 are as follows:
   (1) C249 < 1000: Y10: ON. Y11 & Y12: OFF.
   (2) 1000 ≤ C249 ≤ 2000: Y10, Y12: OFF. Y11: ON.
   (3) C249 > 2000: Y10, Y11: OFF. Y12: ON.

   The outputs of Y10, Y11 and Y12 are immediate, regardless of the scan cycle.
3. When M0 and X6 are ON at the same time, SM249 will be reset if X0 changes from OFF to ON and the counter counts up, and SM249 will be set if X1 changes from OFF to ON and the counter counts down.
4. When X6 is OFF, C249 stops counting.
5. When M0 and X6 are both ON, if X2 is ON, C249 will be cleared, and C249 auxiliary contact will be reset.

6.10.6 DHST: High-speed Counting Table Compare Instruction

LAD: DHST (S1) (S2) (S3)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DHST (*S1*) (*S2*) (*S3*)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT								D						
S2	INT	Constant													
S3	DINT										C				

Operand description

S1: the starting D element for table comparison. The following three D elements are the comparison data, SN of Y element and the output state. These four D elements form a record.

S2: the number of records for comparison. Range: 1 ~ 128.

S3: high speed counter. Range: C236 ~ C255.

Function description

1. A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON.
2. When the counter value equates the comparison data of the present record, the corresponding Y element will be output.
3. The Y element specified in the present record will be output immediately, regardless of the scan cycle.
4. You can use the DHST instruction when you want to immediately output, according to certain comparison data, the Y elements specified in a certain table.

Note

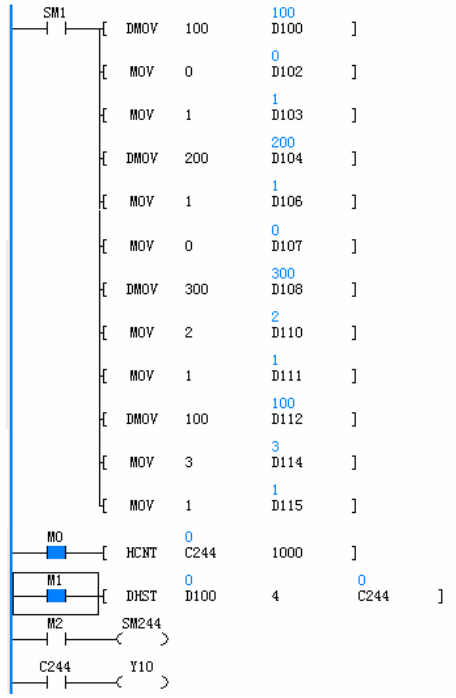
1. The DHST instruction must work together with the HCNT instruction, because DHST is only applicable to the high speed counters that is driven by HCNT.
2. The DHST instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.
3. DHST (DHSCI, DHSCS, DHSCR, DHSP, DHSZ) can be used repeatedly. However, at most six such instructions can be driven at the same time.
4. In a user program, the DHSP and DHST instructions cannot be valid at the same time. That means a valid DHST (or DHSP) instruction will make the following DHSP (or DHST) instructions invalid.
5. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O.*

Example

The table for comparison is shown below:

Comparison data		Y element	Set/Reset	Operation flow
Most significant bit	Least significant bit			
D100=0	D101=100	D102=0	D103=1	1 ↓
D104=0	D105=200	D106=1	D107=0	2 ↓
D108=0	D109=300	D110=2	D111=1	3 ↓
D112=0	D113=300	D114=3	D115=1	4 ↓ Return to 1

The following is the user program:




```
LD      SM1
DMOV  100  D100
MOV    0   D102
MOV    1   D103
DMOV  200  D104
MOV    1   D106
MOV    0   D107
DMOV  300  D108
MOV    2   D110
MOV    1   D111
DMOV   100  D112
MOV    3   D114
MOV    1   D115
LD      M0
HCNT  C244  1000
LD      M1
DHST  D100  4  C244
LD      M2
OUT     SM244
LD      C244
OUT     Y10
```

1. In the first user-program scan cycle, assign elements D100 ~ D115 with values to generate the table for comparison.

2. When M0 and X6 are both ON, the C244 will count when X0 changes from OFF to ON (for the input frequency, see *Chapter 8 Using High Speed I/O*). When C244 changes from 999 to 1000, the C244 contact will be set; when C244 changes from 1001 to 1000, the C244 contact will be reset. When the C244 contact drives Y10, the execution of Y10 will be determined by the user program scan cycle.

3. When M1 is ON, and the DHST instruction meets the requirements in the preceding “Note”, the compare will start with the first record. The compare with the second record will not start until the first compare is over and the corresponding Y element has been output. After the compare with the last record is over, the compare with the first record will start again, and SM185 will be set. SD184 is the SN of the present record, and SD182 & SD183 are the present data for comparison. The corresponding output will be immediate, regardless of the scan cycle.

4. When M2 is ON, SM244 is ON, and C244 will count down. If M2 is OFF, SM244 is OFF, and C244 will count up.

5. When X6 is OFF, C244 is invalid.

6. When M0 and X6 are both ON, if X2 is ON, C244 will be cleared, and C244 auxiliary contact will be reset.

6.10.7 DHSP: High-speed Counting Table Compare Pulse Output Instruction

LAD: DHSP (S1) (S2) (S3)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DHSP (*S1*) (*S2*) (*S3*)	Program steps	10

Operand	Type	Applicable elements													Offset addressing
S1	DINT								D						
S2	INT	Constant													
S3	DINT										C				

Operand description

S1: the starting D element for table comparison. The following three D elements are the comparison data, and the data to output to SD180 & SD181. These four D elements form a record.

S2: the number of records to be compared. Range: 1 ~ 128.

S3: high speed counter. Range: C236 ~ C255.

Function description

1. A high-speed counter will count in the interrupt mode only when it is driven by the HCNT instruction and the counting input changes from OFF to ON.
2. When the counter value equates the comparison data of the present record, the output data of the present record will become the values of SD180 & SD181.
3. You can use the DHSP instruction when you want to control the high speed output or assign values to certain parameters according to a table. For example, you can set the SD180 & SD181 (double word) as the output frequency of the PLSY instruction, and the PLSY output frequency will be adjusted by the table compare result.

Note

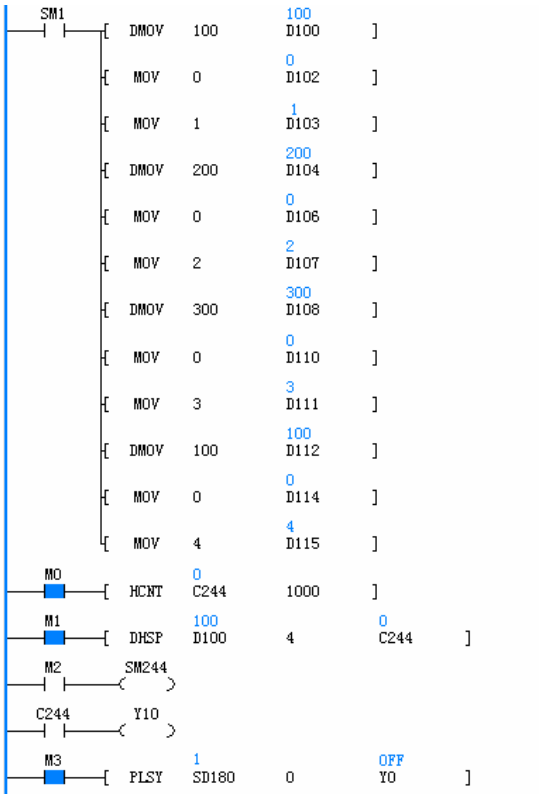
1. The DHSP instruction must be used together with the HCNT instruction, because the DHST instruction cannot be executed unless the related high speed counter is driven by the HCNT instruction.
2. When the DHSP instruction is used together with the PLSY instruction, the values assigned to SD180 and SD181 must meet the frequency output requirement of the PLSY instruction. For details, see the description of the PLSY instruction.
3. To stop the comparison at the last record, set the last output data of the table as 0. Under this situation, other DHST and DHSP instructions will be invalid. But at this time, the DHSP instruction is not regarded as a high speed instruction when it comes to the number limit of high-speed instructions.
4. The DHSP instruction will be validated only by pulse input. You cannot validate the instruction by changing the counter value with instructions such as DMOV or MOV.
5. DHSP (DHSCI, DHSCS, DHSCR, DHST, DHSZ) can be used repeatedly. However, at most the first six such instructions can be driven at the same time.
6. In a user program, the DHSP and DHST instructions cannot be valid at the same time. That means a valid DHSP (or DHST) instruction will make the following DHST (or DHSP) instructions invalid.
7. The maximum frequency supported by the PLC high speed counters will be seriously affected by instructions like DHSCS, DHSCI, DHSCR, DHSZ, DHSP and DHST. For details, see *Chapter 8 Using High Speed I/O*.

Example

The table for comparison is shown below:

Comparison data		Output data (to SD180 & SD181)		Operation flow
Most significant bit	Least significant bit	Most significant bit	Least significant bit	
D100=0	D101=100	D102=0	D103=1	1 ↓
D104=0	D105=200	D106=0	D107=2	2 ↓
D108=0	D109=300	D110=0	D111=3	3 ↓
D112=0	D113=300	D114=0	D115=4	4 ↓ Return to 1

The following is the user program:




```
LD      SM1
DMOV    100   D100
MOV     0     D102
MOV     1     D103
DMOV    200   D104
MOV     0     D106
MOV     2     D107
DMOV    300   D108
MOV     0     D110
MOV     3     D111
DMOV    100   D112
MOV     0     D114
MOV     4     D115
LD      M0
HCNT    C244  1000
LD      M1
DHSP    D100  4   C244
LD      M2
OUT     SM244
LD      C244
OUT     Y10
LD      M3
PLSY    SD180 0   Y0
```

1. In the first user-program scan cycle, assign elements D100 ~ D115 with values to generate the table for comparison.
2. When M0 and X6 are both ON, C244 will count when X0 changes from OFF to ON (for the input frequency, see *Chapter 8 Using High Speed I/O*). When C244 changes from 999 to 1000, the C244 contact will be set; when C244 changes from 1001 to 1000, the C244 contact will be reset. When the C244 contact drives Y10, the execution of Y10 will be determined by the user program scan cycle.
3. When M1 is ON, and the DHSP instruction meets the requirements in the preceding “Note”, the compare will start with the first record. The compare with the second record will not start until the first compare is over and the output data has been output to SD180 & SD181. After the compare with the last record is over, the compare with the first record will start again, and SM185 will be set. SD184 is the SN of the present record, and SD182 & SD183 are the present data for comparison. The output data will be output to SD180 & SD181 immediately, regardless of the scan cycle. If you want to stop the at the last record, set the output data of the last record to 0.
4. When M2 is ON, and SM244 is ON, C244 will count down. When M2 is OFF, and SM244 is OFF, C244 will count up.
5. When X6 is OFF, C244 is invalid.
6. When M0 and X6 are both ON, if X2 is ON, C244 will be cleared, and the C244 contact will be reset.

6.10.8 SPD: Pulse Detection Instruction

LAD: SPD (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: SPD (*S1*) (*S2*) (*D*)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	BOOL		X												
S2	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD								D				V		√

Operand description

S1: input point. Range: X0 ~ X5.

S2: time unit for input point detection. Unit: ms. Operand S2 > 0.

D: the storage register for the counted pulse number, which will cause overflow when bigger than 65535.

Function description

To detect the number of pulses input through X0 ~ X5 in the specified period of time (ms) and store the result in the designated storage register.

Note

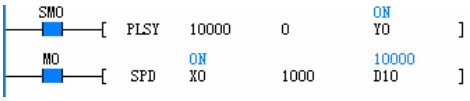
1. SPD and HCNT are contradictory in their occupation of hardware. For details, see *Chapter 8 Using High Speed I/O.*

2. The SPD instruction supports only input points X0 ~ X5.

3. Maximum pulse input frequency: 10kHz. Detection may be faulty when frequency is higher than 10kHz.

4. The input frequency of SPD must be subject to the limit of system total pulse frequency.

Example



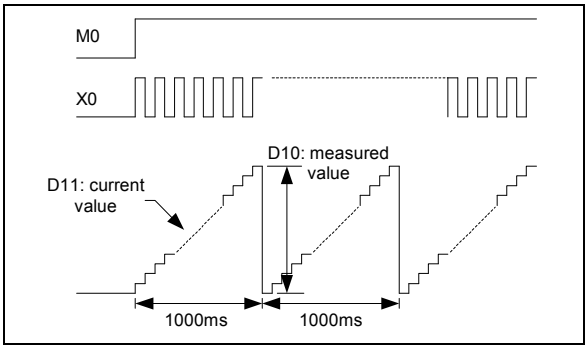
LD SM0

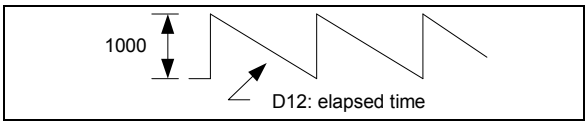
PLSY 10000 0 Y0

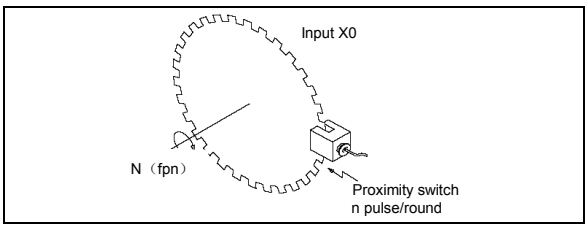
LD M0

SPD X0 1000 D10

The time sequence chart of the example program is shown below:







1. When M0 is ON, count the pulses input through X0 within 1000ms, and store the counting result in D10. D11 is the present counting value within the 1000ms, while D12 is the elapsed time within the 1000ms.

2. D10 is in positive proportion to the rotary speed of the plate in the preceding figure.

3. D10 counts whenever X0 changes from OFF to ON, and the counting value within the last 1000ms will be stored in D10.

6.10.9 PLSY: Count Pulse Output Instruction

LAD: PLSY (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: PLSY (*S1*) (*S2*) (*D*)	Program steps	9

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	BOOL			Y											

Operand description

S1: specified frequency (Hz). Range: 1 ~ 100,000 (Hz). When ***S1*** is outside this range, the system will report instruction operand error, and no hardware resources will be occupied.

Change ***S1*** during the execution of the instruction will change the output frequency in real time.

S2: output pulse number (PLS).

Range: 0 ~ 2147483647. When ***S2*** is outside this range, the system will report instruction operand error, output no pulse, and no hardware resources will be occupied. When ***S2*** is 0, the pulse will output so long as the instruction is valid. If you change ***S2*** during the execution of the instruction, the change will be take effect in the next round.

D: high speed pulse output point. Range: Y0, Y1.

Function description

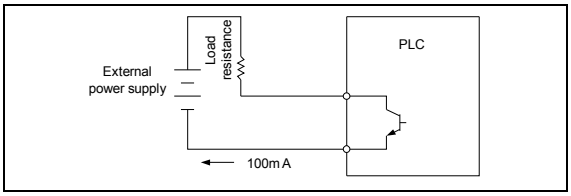
To output specified amount of high speed pulses at the specified frequency. For that purpose, the load current on the PLC output transistor should be big, but below the rated load current.

Note

1. The PLC must use the transistor output mode.

2. When the PLC outputs high-frequency pulses, the following load current for the PLC output transistor must be used.

3. The output loop (transistor) for PLSY, PWM and PLSR is shown as follows:



4. With large load, the transistor off time is relatively longer. The PWM, PLSY and PLSR instructions require that the transistor output terminal be connected to their corresponding loads. When the output waveform does not conform to the instruction operand, increase the load current of the transistor (the transistor load current ≤100mA).

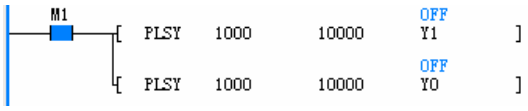
5. During or after the execution of the high-speed instruction, no other instructions can use the same port, unless the high speed pulse output instruction is invalid.

6. Using two PLSY instructions can output two independent pulses at Y0 and Y1. You can also use PLSY and the PWM (or PLSR) instructions to get independent pulse outputs at different output ports (Y0, Y1).

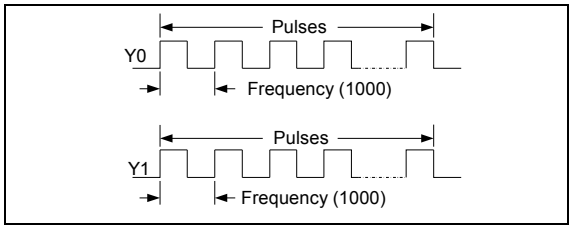
7. When multiple PWM, PLSY or PLSR instructions work on the same output point, the first valid instruction will control the state of the output point, and others will not affect the output point state.

8. Just like other high speed instructions (DHSCS, DHSCR, DHSZ, DHSP, DHST and HCNT), the PLSY instruction must meet the system's requests on high speed I/O.

Example




```
LD   M1
PLSY 1000 10000 Y1
PLSR 1000 10000 Y0
```



1. When M1 is ON, 10,000 pulses will output through Y0 and Y1 at the frequency of 1000Hz. Then the pulse output will stop until M0 changes from OFF to ON when the next round of output will start. When M0 is OFF, there will be no output.

2. The duty cycle of the pulses is 50%. The output is handled in the interrupt mode, free from the scan cycle. For high frequency output, the output duty cycle at Y points is related to the load. The waveform at output points (Y0 & Port 0, Y1 & Port 1) is related to the load: so long as the current does not exceed

the rated load current, the smaller the load is, the closer the output wave form is to the set operand.

3. SM80 & SM81 controls the ON/OFF of the output at Y0 and Y1 respectively. When SM80 or SM81 is 1, the output is ON.

4. SM82 & SM83 are the output monitors of Y0 & Y1 respectively. SM82 or SM83 will be OFF after the output is complete.

5. SD50: the MSB of the output pulse number at Y0 for PLSY and PLSR instructions.

SD51: the LSB of the output pulse number at Y0 for PLSY and PLSR instructions.

SD52: the MSB of the output pulse number at Y1 for PLSY and PLSR instructions.

SD53: the LSB of the output pulse number at Y1 for PLSY and PLSR instructions.

SD54: the MSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

SD55: the LSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

6. SD50 ~ SD55 can be changed with the instruction DMOV or MOV, or through the ConstrolStar software.

7. Refer to the DHSP instruction if you want to use the input pulse number to control the PLSY output pulse frequency.

6.10.10 PLSR: Count Pulse With Acceleration/Deceleration Output Instruction

LAD: PLSR (S1) (S2) (S3) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: PLSR (*S1*) (*S2*) (*S3*) (*D*)	**Program steps**	**10**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S3	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D1	BOOL			Y											

Operand description

S1: maximum frequency. Range: 10 ~ 20,000 (Hz). When ***S1*** is specified indirectly, and if the specified value is outside this setting range, it will be regarded as 10 or 20,000, depending on which limit it breaks. In that case, the system will report operand illegal, and the high speed pulse output will be based on the default 10Hz or 20,000Hz.

S2: total output pulse number (PLS). Range: 110 ~ 2147483647. When ***S2*** is outside this range, the system will report instruction operand error, output no pulse, and no hardware resources will be occupied.

S3: acceleration or deceleration time (ms). If ***S1*** × ***S3*** < 100,000, ***S3*** will be regarded as 100000/***S1***. Meanwhile the system will report instruction operand error, and the acceleration or deceleration time will be uncertain.

If ***S1*** × ***S3*** > ***S2*** × 909, ***S3*** will be regarded as S2 × 909/***S1***. Meanwhile the system will report instruction operand error, and the acceleration or deceleration time will be uncertain.

Note

For IVC1, the acceleration / deceleration time must not be smaller than 50ms.

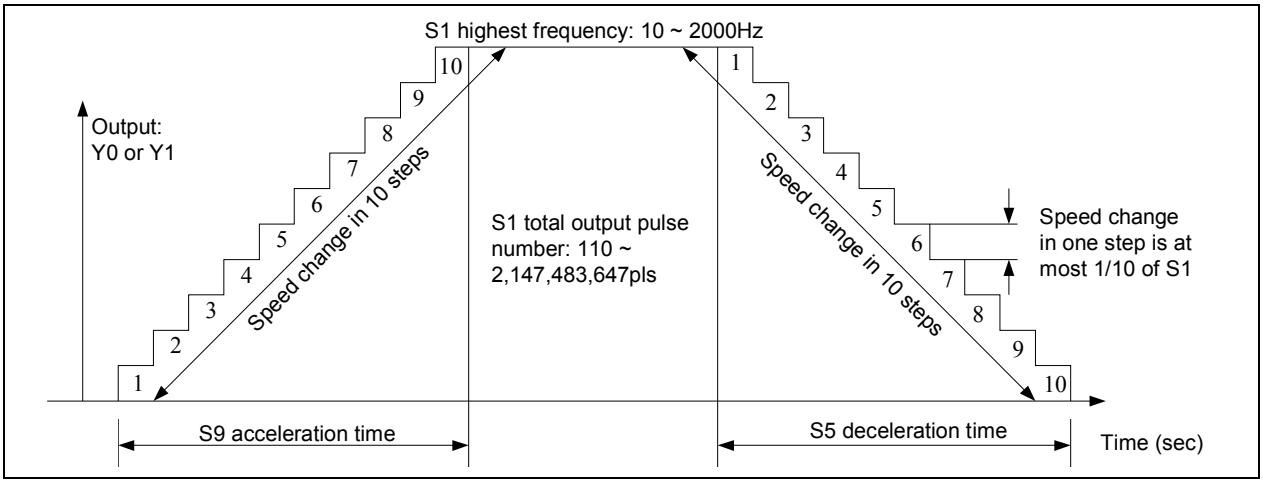
The speed change is evenly divided into 10 steps during the acceration or deceleration, each step being ***S1***/10.

D: high speed pulse output point. Range: Y0, Y1.

Function description

The PLSR instruction is a high speed pulse output instruction with acceleration / deceleration function. It is used for locating. Targeting at the specified maximum frequency, the pulse output will accelerate evenly. After the output pulse number reaches the preset value, the pulse output will decelerate evenly.

The operation process is shown in the following figure:


S1 highest frequency: 10 ~ 2000Hz
Output:
Y0 or Y1
Speed change in 10 steps
S1 total output pulse number: 110 ~ 2,147,483,647pls
Speed change in 10 steps
Speed change in one step is at most 1/10 of S1
S9 acceleration time
S5 deceleration time
Time (sec)

Note

1. The output frequency of this instruction is 10 ~ 20,000Hz. When the acceleration / deceleration rate exceeds that range, it will be automatically adjusted according to that range.This instruction is free from the influence of the scan cycle.

2. Use the transistor output. During the high speed pulse output, the output current must comply with the related regulations. The waveform at output points (Y0 & Port 0, Y1 & Port 1) is related to the load: so long as the current does not exceed the rated load current, the smaller the load is, the closer the output waveform is to the set operand.

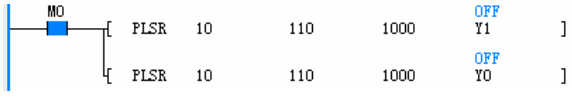
3. During the execution of the high-speed instruction, so long as the power flow is not OFF, no other instructions can use the same port, unless the high speed pulse output instruction is invalid.

4. Using two PLSR instructions can output two independent pulses at Y0 and Y1. You can also use PLSR and the PWM (or PLSY) instruction to get independent pulse outputs at different output ports (Y0, Y1).

5. When multiple PWM, PLSY or PLSR instructions work on the same output point, the first valid instruction will control the state of the output point, and others will not affect the output point state.

6. Just like other high speed instructions (DHSCS, DHSCR, DHSZ, DHSP, DHST and HCNT), the PLSR instruction must meet the system's requests on high speed I/O.

Example




```
LD    M0
PLSR  10  110  1000  Y1
PLSR  10  110  1000  Y0
```

1. When M0 is ON, Y0 and Y1 output 110 pulses respectively at set frequencies. When M0 changes from OFF to ON, pulses will be output again. When M0 is OFF, the output will stop.

2. The operand change during the execution of the instruction will not be valid until the next time this instruction is executed.

3. SM80 & SM81 controls the ON/OFF of the output at Y0 and Y1 respectively. When SM80 or SM81 is 1, the output is ON.

4. SM82 & SM83 are the output monitors of Y0 & Y1 respectively. SM82 & SM83 will be ON when the output is going on, or OFF when the output is over.

5. SD50: the MSB of the output pulse number at Y0 for PLSY and PLSR instructions.

SD51: the LSB of the output pulse number at Y0 for PLSY and PLSR instructions.

SD52: the MSB of the output pulse number at Y1 for PLSY and PLSR instructions.

SD53: the LSB of the output pulse number at Y1 for PLSY and PLSR instructions.

SD54: the MSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

SD55: the LSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

6. SD50 ~ SD55 can be changed with the instruction DMOV or MOV, or through the AutoStation software.

6.10.11 PLS: Pulse Output Instruction of Envelope

LAD: ⊣⊢ ⊢[PLS (S1) (S2) (D1)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: PLS (*S1*) (*S2*) (*D1*)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D1	BOOL			Y											

Operand description

S1: the starting D element

S2: output section number. Range: 0 ~ 255

D1: high speed pulse output point. Range: Y0, Y1.

Function description

1. Use the ControlStar instruction wizzard to generate the PLS instruction, which can be called like subprograms. When the power flow is ON, the system will output corresponding pulses according to the configuration. You can control ON or OFF of the PG, and set frequency & pulse number.

2. There is no output when the section number is 0.

3. SM80 and SM81 can be used to stop the high speed pulse output. Other flag bits are the same as other high speed I/O instructions.

4. The subprogram PLS_SET generated by the AutoStation is as follows (n: D element addr. M: total section number):

LD SM0
DMOV section 1 step frequency Dn
DMOV section 1 step pulse number Dn + 2
DMOV section 2 step frequency Dn + 4
DMOV section 2 step pulse number Dn+ 6
DMOV section 3 step frequency Dn + 8
DMOV section 3 step pulse number Dn + 10
...
DMOV section M step frequency Dn + 4M - 4
DMOV section M step pulse number Dn + 4M - 2
DMOV max. speed Dn + 4M
MOV min. speed Dn + 4M + 2
MOV acceleration time Dn + 4M + 3
MOV deceleration time Dn + 4M + 4

Note

1. It is recommended to use the PTO instruction wizard to generate PLS instruction. If you write the PLS instruction manually, note that the pulse number of the steps must not be too small. With set acceleration, the pulse number of each step must be bigger than the min. pulse number required by frequency transfer.

2. Use P to stand for the pulse number that a certain step outputs; F_N: frequency of section N; $F_{\max}$: the maximum speed; $F_{\min}$: the maximum speed; T_{up}: the acceleration time; T_{down}: the deceleration time.

1) When the speed of step N is bigger than that of step N-1, the pulse number of step N must meet the following condition:

$$P \geq \frac{(F_N + F_{N-1}) \times (F_N - F_{N-1}) \times T_{up}}{2000 \times (F_{\max} - F_{\min})}$$

2) When the speed of step N is smaller than that of step N - 1, the pulse number of step N must meet the following condition:

$$P \geq \frac{(F_N + F_{N-1}) \times (F_N - F_{N-1}) \times T_{down}}{2000 \times (F_{\max} - F_{\min})}$$

3. In particular,

1) when N = 1, the frequency of step N – 1 is used instead of $F_{\min}$ in the above format.

2) when all the step number is 1, that is to say, only one section, the pulse number must meet the following condition:

$$P \geq \frac{(F_1 + F_{\min}) \times (F_1 - F_{\min}) \times (T_{up} + T_{down})}{2000 \times (F_{\max} - F_{\min})}$$

3) The pulse number of the last step must meet the following format:

$$P \geq \frac{(F_M + F_{M-1}) \times (F_M - F_{M-1}) \times (T_{up} + T_{down})}{2000 \times (F_{\max} - F_{\min})}$$

4) the frequency set in every step must be within the range of maximum speed and minimum speed.

5) The maximum total pulse number of all steps is 999,999.

4. Use the transistor output. During the high speed pulse output, the output current must comply with the related regulations. The waveform at output points (Y0 & Port 0, Y1 & Port 1) is related to the load: so long as the current does not exceed the rated load current, the smaller the load is, the closer the output waveform is to the set operand.

5. During the execution of the high-speed instruction, so long as the power flow is not OFF, no other instructions can use the same port, unless the high speed pulse output instruction is invalid.

6. The PLSY, PLSR, PLS and locating instructions can output high speed pulses through Y0 and Y1. Note that only one instruction can use one output port at one time.

6.10.12 PWM: Pulse Output Instruction

LAD: PWM (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: PWM (*S1*) (*S2*) (*D*)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Operand	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Operand	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	BOOL			Y											

Operand description

S1: pulse width (ms).

Range: 0 ~ 32767 (ms). When ***S1*** is bigger than 32767, the system will report illegal instruction operand, and no hardware resources will be occupied.

You can change the output pulses in real-time by changing ***S1*** during the execution of the instruction.

S2: pulse cycle (ms).

Range: 1 ~ 32767. When S2 is outside the range, the system will report illegal instruction operand, no pulse will be output, and no system resources will be occupied.

You can change the output pulses in real-time by changing ***S2*** during the execution of the instruction.

S2 must be bigger than ***S1***, or the system will report illegal instruction operand, no pulse will be output, and no system resources will be occupied.

D: high speed pulse output point (Y0 or Y1)

Function description

Output PWM pulses with the width of ***S1*** and cycle of ***S2*** at the port designated by ***D***.

Note

1. When ***S1*** is 0, Y0 or Y1 output is OFF. When ***S1*** is equates ***S2***, Y0 or Y1 output is ON.

2. The waveform at output points (Y0 & Port 0, Y1 & Port 1) is related to the load: so long as the current does not exceed the rated load current, the smaller the load is, the closer the output waveform is to the set operand. Therefore, in order to output high speed pulses, the load current at the PLC output transistor must be big, but smaller than the rated load current.

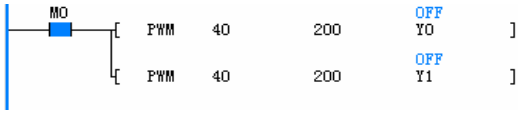
3. During the execution of the high-speed instruction, so long as the power flow is not OFF, no other instructions can use the same port, unless the high speed pulse output instruction is invalid.

4. Using two PWM instructions can output two independent pulses at Y0 and Y1. You can also use the PLSY and PLSR instructions to get independent pulse outputs at different output ports (Y0, Y1).

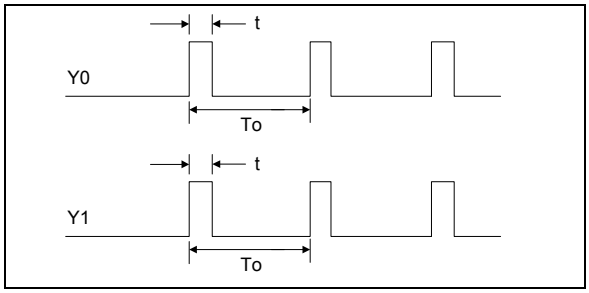
5. When multiple PWM, PLSY or PLSR instructions work on the same output point, the first valid instruction will control the state of the output point, and others will not affect the output point state.

6. Just like other high speed instructions (DHSCS, DHSCR, DHSZ, DHSP, DHST and HCNT), the PWM instruction must meet the system's requests on high speed I/O.

Example




```
LD   M0
PWM  40  200  Y0
PWM  40  200  Y1
```



Where "t" is the pulse width and T0 is the pulse cycle.

1. When M0 is ON, Y0 and Y1 output PWM pulses with the width of 40ms and cycle of 200ms. When M0 is OFF, the output will stop. The output state is not affected by the scan cycle.

2. SM80 and SM81 control the output ON/OFF of Y0 and Y1 respectively. When SM80 and SM81 are ON, the output will stop.

3. SM82 and SM83 monitor the output of Y0 and Y1 respectively. When M0 is OFF, SM82 and SM83 are OFF.

6.11 Control Calculation Instruction

6.11.1 PID: PID Instruction

LAD: PID (S1) (S2) (S3) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: PID (S1) (S2) (S3) (D)	**Program steps**	**9**

Operand	Type	Applicable elements													Offset addressing
S1	INT								D						√
S2	INT								D						√
S3	INT								D						√
D	INT								D						√

Operand description

D: calculation result output after the program is executed (MV)

S1: preset value (SV)

S2: current value (PV)

S3: sampling time (Ts). Range: 1 ~ 32767 (ms). It must be set bigger than the calculation time.

S3+1: action, alarm and thresholds setting

Bit	Value and meaning	
	0	1
0	Forward	Reverse
1	Process Value alarm disabled	Process Value alarm enabled
2	Output value alarm disabled	Output value alarm enabled
3 ~ 4	Reserved	
5	Output threshold setting disabled	Output threshold setting enabled
6 ~ 15	Reserved	

S3+2: input filter constant (α). Range: 0 ~ 99 [%]. Zero means no input filtering function.

S3+3: proportional gain (Kp). Range: 1 ~ 32767 [%].

S3+4: integral time constant (TI). Range: 0 ~ 32767 (×100ms). Zero means limit, or no integral.

S3+5: differential gain (KD). Range: 0 ~ 100[%]. Zero means no differential gain.

S3+6: differential time (TD). Range: 0 ~ 32767 (×10ms). Zero means no differential processing.

S3+7 ~ ***S3+14***: internal data register for PID operation

S3+15: PID process value (positive change) alarm point. Range: 0 ~ 32767 (when bit 1 of ***S3+1*** is 1).

S3+16: PID process value (negative change) alarm point. 0 ~ 32767 (when bit 1 of ***S3+1*** is 1).

S3+17: PID output value (positive change) alarm point 0 ~ 32767 (when bit 2 & bit 5 of ***S3+1*** are 1 & 0 respectively).

Output upper limit: -32768 ~ 32767 (when bit 2 & bit 5 of ***S3+1*** are 0 & 1 respectively).

S3+18: PID output value (negative change) alarm point. Range: 0 ~ 32767 (when bit 2 & bit 5 of ***S3+1*** are 1 & 0 respectively).

Output lower limit: -32768 ~ 32767 (when bit 2 & bit 5 of ***S3+1*** are 0 & 1 respectively).

S3+19: PID alarm output

- Bit 0 process value (positive change) overflows
- Bit 1 process value (negative change) overflows
- Bit 2 output value (positive change) overflows
- Bit 3 output value (negative change) overflows

Where, S3 ~ S3 + 6 are the mandatory user set operands, while S3 + 15 ~ S3 + 19 are optional user set operands. You can set the operands through the PID instruction wizard of the AutoStation.

Function description

1. PID calculation will be carried out when the power flow is ON and it is the sampling time.

2. Multiple PID instructions can be executed simultaneously (no limit on the loop number). However, note that the elements used as S1, S2, S3 or D should be different.

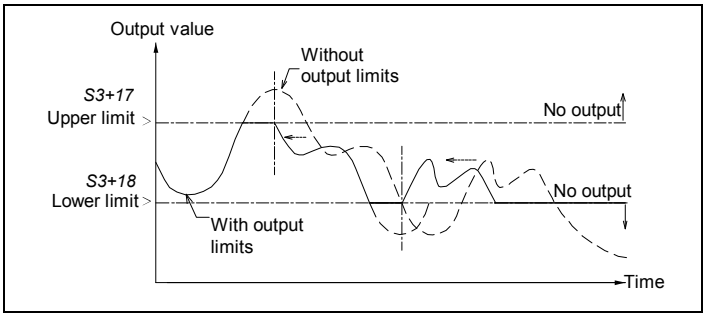
3. The PID instruction is applicable to timed interrupt subprograms, ordinary subprograms and the main program. Note that before using the PID instruction, confirm the operand settings and clear the internal data registers ***S3***+7 ~ ***S3*** + 14 first.

4. The input filtering constant can smooth the change of measured value.

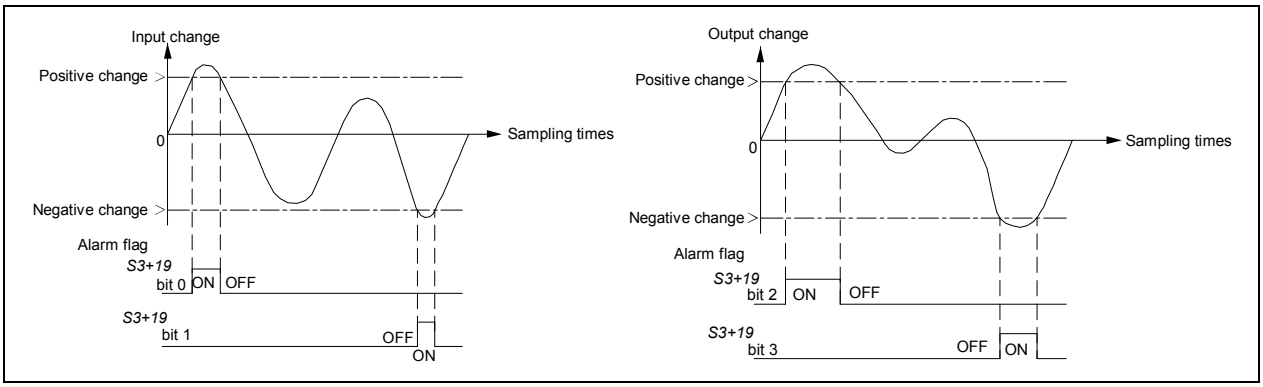
5. The differential gain can smooth the change of output value.

6. Action direction: bit 0 of ***S3+1*** is used to set the forward (positive reactioin) and reverse (negative reaction) of the system.

7. Output thresholds: when the output threshold setting is enabled (bit 5 & bit 2 of ***S3+1*** are 1 and 0 respectively), the integral of PID can be controlled from becoming too big. The output value is shown as below:



8. Alarm setting: when the output thresholds are set valid (in ***S3+1***, bit 1 is 1, BIT2 is 1 and bit 5 is 0), the PID instruction will compare the current value with the preset value in ***S3+15 ~ S3 + 18***. If the current value is bigger than the preset value, PID will report alarm, and the corresponding bits in ***S3+19*** will be set. In this way you can monitor the input change and output change. See the following figures.



9. Basic PID equations:

Direction	PID equations
Forward	$\Delta MV = KP\left\{\left(EV_n - EV_{n-1}\right) + \frac{T_S}{T_I}EV_n + D_n\right\}$ $EV_n = PV_{nf-1} - SV$ $D_n = \frac{T_D}{T_S + \alpha_D * T_D}\left(PV_{nf} + PV_{nf-2} - 2PV_{nf-1}\right) + \frac{\alpha_D * T_D}{T_S + \alpha_D * T_D} * D_{n-1}$ $MV_n = \sum \Delta MV$
Reverse	$\Delta MV = KP\left\{\left(EV_n - EV_{n-1}\right) + \frac{T_S}{T_I}EV_n + D_n\right\}$ $EV_n = SV - PV_{nf-1}$ $D_n = \frac{T_D}{T_S + \alpha_D * T_D}\left(2PV_{nf-1} - PV_{nf} - PV_{nf-2}\right) + \frac{\alpha_D * T_D}{T_S + \alpha_D * T_D} * D_{n-1}$ $MV_n = \sum \Delta MV$

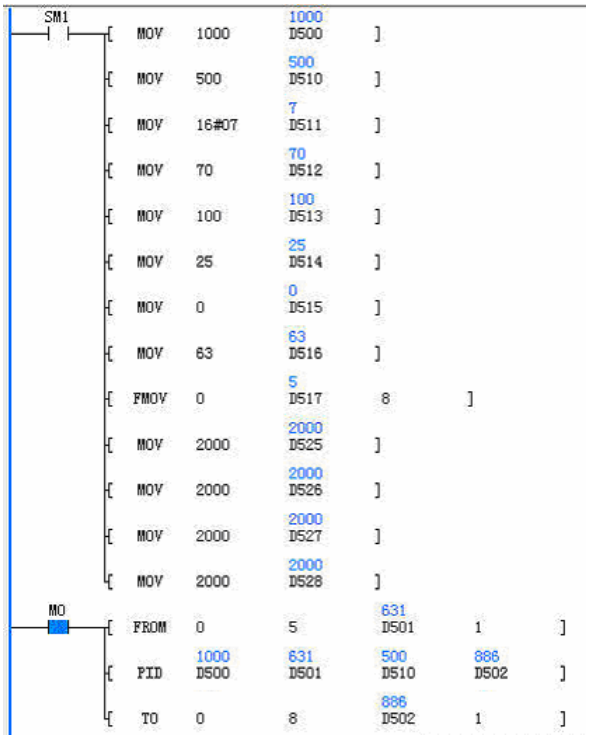
Operand description:

Symbol	Description		Symbol	Description
EV_n	The current Error Value		D_n	The current Differential Value
EV_{n-1}	The previous Error Value		D_{n-1}	The previous Differential Value
SV	The Set Point Value		KP	The Proportion Constant
PV_{nf}	The calculated Process Value		T_S	The Sampling Time
PV_{nf-1}	The previsou Process Value		T_I	The Integral Time Constant
PV_{nf-2}	The second previous Process Value		T_D	The Differential Time
ΔMV	The change in the output Manipulation Values		α_D	The Differential gain
MV	The current output manipulation value			

Example

```
// PID initialization. If the control operands are the same, you can initialize the operands only once.
LD      SM1             //Initialization, executed only once
MOV     1000    D500    //Setting target value
MOV     500     D510    //Sampling time (Ts)  Range: 1 ~ 32767 (ms). It must be bigger than the
                        // calculation time
MOV     7       D511    //Action direction
MOV     70      D512        //Input filtering constant ( α ) Range: 0 ~ 99 [%]. Zero means no input filtering
MOV     100     D513        //Proportional gain (Kp) Range:1 ~ 32767 [%]
MOV     25      D514        //Integral time (TI) Range: 0 ~ 32767 (×100ms). Zero means limit, or no integral
MOV     0       D515        //Differential gain (KD) Range: 0 ~ 100[%]. Zero means no differential gain
MOV     63      D516        //Differential time (TD) Range: 0 ~ 32767 (×10ms). Zero means no differential
                            // processing
FMOV    0       D517    8   //Clearing the memory for the transit data of PID calculation
MOV     2000    D525        //Process value (positive change) alarm setting 0 ~ 32767
MOV     2000    D526        //Process value (negative change) alarm setting 0 ~ 32767
MOV     2000    D527        //Output value (positive change) alarm setting 0 ~ 32767
MOV     2000    D528        //Output value (negative change) alarm setting 0 ~ 32767
//PID instruction execution
LD      M0              //User-controlled PID calculation program
FROM    0   5   D501    1   //Input current measured value (users can input measured values
                            // according to the actual situation)
PID     D500 D501 D510 D502 //PID instruction: PID S1 S2 S3 D
TO      0   8   D502    1   //PID calculation result is fed back to the controlled system (users can
                            // handle the PID calculation result according to the actual situation)
```

The LAD of the above instructions is shown below:



The PLC will initialize the PID operands only in the first scan cycle. When X2 is ON, the current measured value will be read from external A/D module (the actual situation could be different), assigned to the corresponding elements, and the PID calculation will be carried out. The calculation result will be converted into analog signals through the external D/A module (the actual situation could be different) and fed to the controlled system.

Note

1. The operand ***D*** should be a register outside of the Saving Range. Otherwise, it should be cleared (LD SM0 MOV 0 D****) in the first operation.
2. The PID instructions occupies 20 consecutive registers starting with ***S3***.
3. The maximum error of sampling time (TS) is - (scan cycle + 1ms) ~ + (scan cycle). When TS is small, the PID effect will be affected. It is recommended to use PID instruction in the timed interrupt.
4. When setting the PID output thresholds, if the upper limit is smaller than the lower limit, the system will report operand error, and no PID calculation will be carried out.
5. When the process value alarm and output value alarm are enabled, ***S3 + 15 ~ S3 + 18*** cannot be set negative, or the system will report operand error, and no PID calculation will be carried out.

6. Setting bit 2 and bit 5 of ***S3+1*** ON at the same time will be regarded as invalid (essentially the same as setting bit 2 and bit 5 OFF), and there will be no limit, nor output value alarm.

7. When the PID control operands (***S3 ~ S3 + 6***) are set outside their ranges, the system will report operand error, and no PID calculation will be carried out.

8. When the sampling time is smaller than the scan cycle, if there is data overflow or result overflow during the calculation, there will be no alarm, and the PID calculation continues.

9. The PID operands must be initialized before the PID instruction is executed the first time. If the operands remain the same during the operation, and the related operand elements will not be covered by other programs, you can initialize the PID operands only once. However, if the data in the transit data registers are changed during the PID calculation, the calculation result will be incorrect.

6.11.2 RAMP: Ramp Wave Signal Output Instruction

LAD: RAMP (S1) (S2) (D1) (S3) (D2)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: RAMP (S1) (S2) (D1) (S3) (D2)	**Program steps**	**12**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D1	INT								D				V		√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D2	BOOL			Y	M	S	LM				C	T			

Operand description

S1: starting value

S2: end value

D1: output value

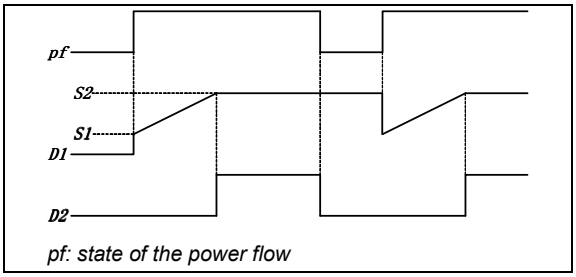
S3: step number. ***S3*** >0, or system will report operand error. and do not execute the calculation.

D2: output state 0

Function description

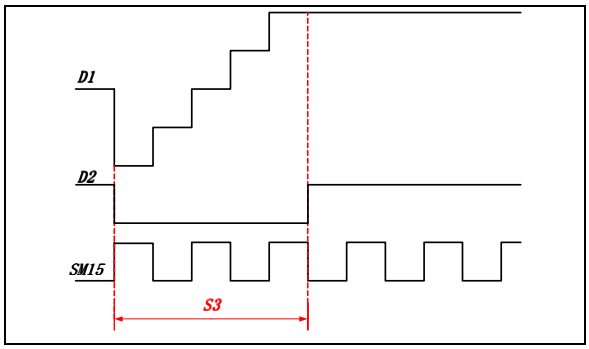
In each scan cycle, when the power flow is ON, this instruction can determine the increment and current output value ***D1*** according to the ramp wave height and step number. When the output value ***D1*** reaches ***S2,*** it will keep stable, and the output state ***D2*** will be set ON. If the power flow falls, the output state ***D2*** will be set OFF, but the output value ***D1*** will not change, until the power flow rises again, when ***D1*** will be initialized as ***S1***, and continue to conduct the next ramp calculation.

See the following figure:



pf: state of the power flow

Analysis of the execution process of the ramp instruction is shown in the following figure (***S3***=5):



Note

1. If the result is not divisible when calculating the program steps, round off to the nearest whole number.

2. The instruction will generate one ramp data upon every rising edge.

3. When ***S1*** = ***S2***, ***D1*** = ***S2***, ***D2*** = ON.

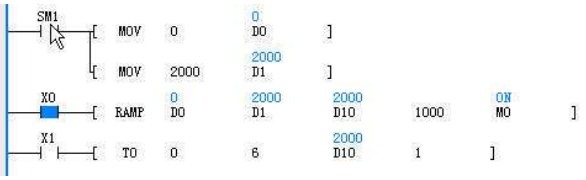
4. The total number of RAMP, HACKLE and TRIANGLE instructions in a program should not exceed 100.

Example

```
//Initialize registers upon the first scan cycle after the power-on
LD      SM1
MOV     0 D0
MOV     2000 D1
//Execute RAMP instruction when X0 is ON
```

```
LD      X0
RAMP    D0 D1 D10 1000 M0
//Output the ramp function result to external DA
module when X1 = ON to generate ramp wave form
LD      X1
TO      0 6 D10 1
```

The LAD of the preceding instructions is shown below:



1. When X0 is ON, D10 (in the first cycle, D10 = D0 = 0) will increase by 2 (2000/1000) in every scan cycle. When D10 = D1 = 2000, D10 will increase no more, and M0 will be ON. During the generation of the ramp function, if the power flow falls, the output state ***D2*** will be OFF, the output value ***D1*** will keep its current value until the next rising edge, when D10 = D0 and a new ramp starts.
2. You can use an external special module to convert the data into analog waveform.

6.11.3 HACKLE: Hackle Wave Signal Output Instruction

LAD: HACKLE (S1) (S2) (D1) (S3) (D2)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: HACKLE (S1) (S2) (D1) (S3) (D2)	**Program steps**	**12**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D1	INT								D				V		√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D2	BOOL			Y	M	S	LM				C	T			

Operand description

S1: starting value

S2: end value

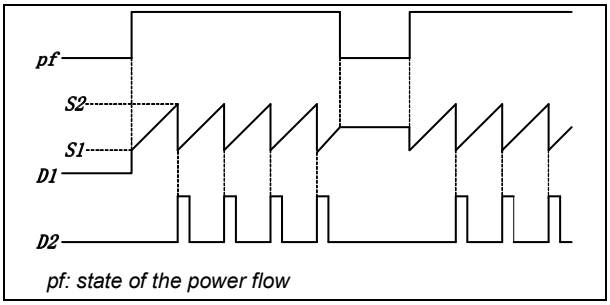
D1: output value

S3: step number. ***S3*** > 0, or system will report operand error. and do not execute the calculation

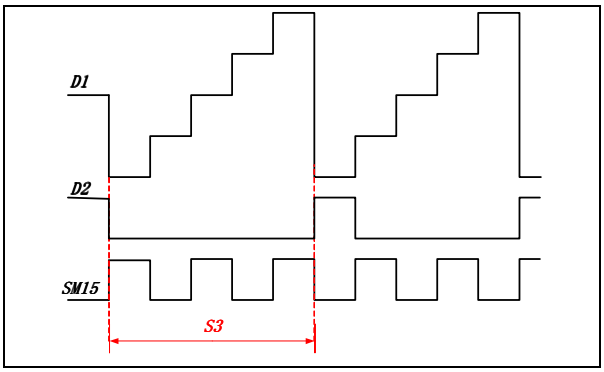
D2: output state

Function description

In each scan cycle, when the power flow is ON, this instruction can determine the increment and current output value ***D1*** according to the hackle wave height and step number. When the output value reaches ***S2***, it will be initialized as ***S1*** and the state output ***D2*** will be set ON. If the power flow in the next scan cycle is still ON, ***D2*** will be set OFF to produce the next hackle wave. If the power flow falls, the output state ***D2*** will be OFF, and the output value ***D1*** will keep its current value until the next rising edge, when the output value ***D1*** will be initialized as ***S1***, and the next hackle wave will be created, as shown in the following figure.



The analysis of the hackle wave instruction is shown in the following figure (***S3***=5):



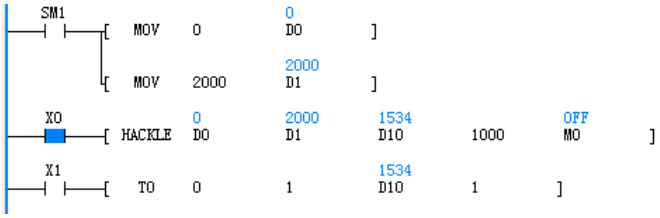
Note

1. If the result is not divisible when calculating the program steps, round off to the nearest whole number.
2. The instruction will generate a series of continuous hackle wave data so long as the power flow keep ON
3. When ***S1*** = ***S2***, ***D1*** = ***S2***, ***D2*** = ON (no counting pulse)
4. The total number of RAMP, HACKLE and TRIANGLE instructions in a program should not exceed 100.

Example

```
//Initialize registers upon the first scan cycle after power-on
LD          SM1
MOV         0 D0
MOV    2000 D1
//Execute HACKLE instruction when X0 is ON
LD          X0
HACKLE      D0 D1 D10 1000 M0
//When X1 is ON, output the result of ramp function to external DA module to generate hackle waveform
LD          X1
TO          0 1 D10 1
```

The LAD for the preceding instruction is shown in the following figure:



1. When X0 is ON, D10 (in the first cycle, D10 = D0 = 0) will increase by 2 (2000/1000) in every scan cycle. When D10 = D1 = 2000, M0 will be ON. In the next scan cycle, if X0 keeps ON, D10 = D0 = 0, and M0 is OFF, the next hackle wave will start. If the power flow falls, the output state ***D2*** will be OFF, but the output value ***D1*** will keep its current value until the next rising edge, when ***D1*** will be initialized as ***S1***, and a new hackle wave starts.
2. You can use an external special module to convert the data into analog waveform.

6.11.4 TRIANGLE: Triangle Wave Signal Output Instruction

LAD: TRIANGLE (S1) (S2) (D1) (S3) (D2)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: TRIANGLE *(S1)* *(S2)* *(D1)* *(S3)* *(D2)*	**Program steps**	**12**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D1	INT								D				V		√
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D2	BOOL			Y	M	S	LM				C	T			

Operand description

S1: starting value

S2: end value

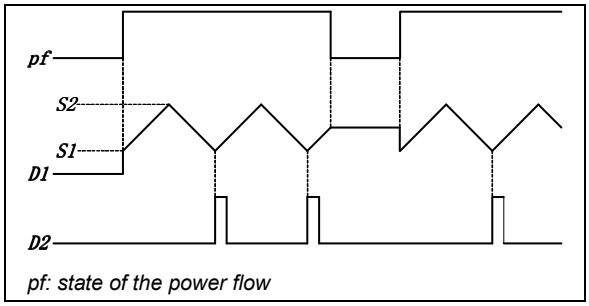
D1: output value

S3: step number. ***S3*** > 0, or system will report operand error, and do not execute the calculation.

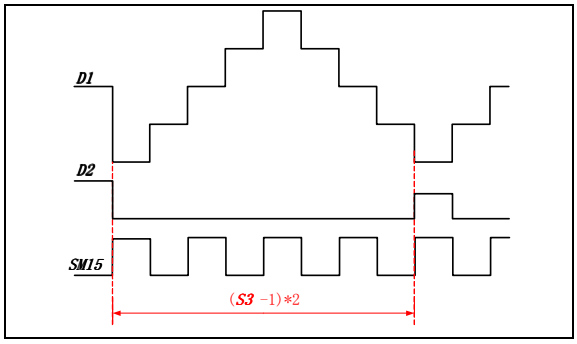
D2: output state

Function description

In each scan cycle, when the power flow is ON, this instruction can determine the increment and current output value ***D1*** according to the triangle wave height and step number. When the output value reaches ***S2***, the rising half of the triangle is complete, the increment direction of the output value will change and generate the falling half of the triangle. When the output value ***D1*** reaches ***S1*** again, the state output ***D2*** will be set ON. In the next scan cycle, if the power flow keeps ON, the state output ***D2*** will be set OFF and the next triangle will be generated. If the power flow falls, the output state ***D2*** will be OFF, the output value ***D1*** will keep its current value until the power flow rises again, when ***D1*** will be initialized as ***S1***, and a new triangle wave will start. See the following figure:



The analysis of the execution of the triangle instruction is shown in the following figure (***S3*** = 5):



Note

1. If the result is not divisible when calculating the program steps, round off to the nearest whole number.
2. The instruction will generate a series of continuous triangle wave data so long as the power flow keep ON
3. When ***S1*** = ***S2***, ***D1*** = ***S2***, ***D2*** = ON (no counting pulse), the cycle of the triangle wave is (***S3*** - 1) × 2.
4. The total number of RAMP, HACKLE and TRIANGLE instructions in a program should not exceed 100.

Example

```
// Initialize registers upon the first scan cycle after power-on
LD          SM1
MOV         0 D0
MOV         2000 D1
//Executie TRIANGLE instruction when X0 is ON
LD          X0
TRIANGLE D0 D1 D10 1000 M0
// When X1 is ON, output the result of ramp function to external DA module to generate triangle waveform
LD          X1
TO          0 1 D10 1
```

The LAD of the preceding instruction is shown in the following figure:

1. When X0 is ON, D10 (in the first cycle, D10 = D0 = 0) will increase by 2 (2000/1000) in every scan cycle. When D10 = D1 = 2000, the rising half of the triangle is complete, and D10 will decrease by 2 in every scan cycle that follows. When D10 = D0 = 0, a complete triangle is complete, and M0 is ON. In the next scan cycle, if X0 keeps ON, and M0 is OFF, the next triangle wave will start. If the power flow falls, the output state ***D2*** will be OFF, but the output value ***D1*** will keep its current value until the next rising edge, when ***D1*** will be initialized as ***S1***, and a new triangle wave starts.
2. You can use an external special module to convert the data into analog waveform.

6.12 Communication Instruction

6.12.1 Modbus: Modbus Master Station Communication Instruction

LAD: ⊣⊢ ⊢[MODBUS (S1) (S2) (S3)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: Modbus (*S1*) (*S2*) (*S3*)	**Program steps**	**8**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	INT	D	V												
S3	INT	D													√

Operand description

S1: designated communication channel

S2: starting address of the data to be transmitted

S3: starting address for storing the received data

Function description

1. When being a master station, when the input conditions are met, the system will transmit the data stored in the unit starting with ***S2***, and then receive the data and save it to the unit starting with ***S3***.

2. When being a slave station, the system needs no instruction control for transceiving data.

3. This instruction is executed upon the rising edge.

Note

1. Sending data through Modbus, whether the data is in RTU mode or ASCII mode, you only need to store the RTU-mode data into the unit starting with ***S2***. You do not need to store the starting character, ending character and checksum, because they will be added to the data automatically in the sending process.

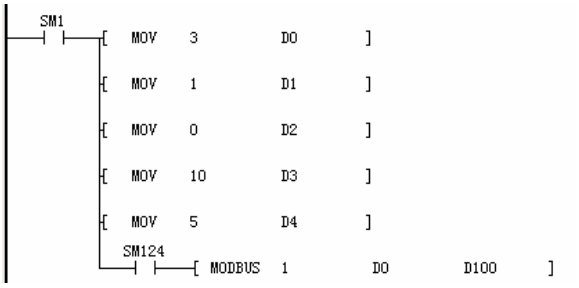
2. You do not need to set the length for the data to be sent. The system will set the length automatically based on the instruction.

S2	Slave address
S2+1	Function code
S2+2	Data 1
	...
S2+N+1	Data N

3. The data, when received through Modbus, will be stored in RTU-mode, regardless of whether you set it in RTU mode or ASCII mode. That is, when you set the data to ASCII mode, the system will automatically convert them to hexadecimal, remove the starting character and ending character, and save them in the data area starting with ***S3***.

4. The sent and received data are stored in the low bytes of the word element. High bytes are not used.

Example



LD SM1

MOV 3 D0

MOV 1 D1

MOV 0 D2

MOV 10 D3

MOV 5 D4

AND SM124

Modbus 1 D0 D100

1. Store the data sent through Modbus into the element starting with D0.

2. Store the data received in the elements starting with D100.

3. After receiving data through Modbus, the system will conduct CRC check, address check and instruction check. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

The communication error codes are shown below:

Code	Description
0x01	Illegal instruction
0x02	Illegal register address
0x03	Wrong number of data
0x10	Communication timeout. The communication exceeds the preset communication time limit
0x11	Error in receiving data frame
0x12	Operand error. Operand (mode or master/slave) setting error
0x13	Error occurs because t he local station SN is the same as that set by the instruction

For the detailed application methods, see *Chapter 10 Using Communication Function*.

6.12.2 IVFWD: FREQUENCY CONVERTER Forward Rotation Instruction

LAD: IVFWD (S1) (S2)	**Applicable to**	**IVC1**
	Influenced flag bit	
IL: IVFWD (*S1*) (*S2*))	**Program steps**	**6**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	WORD	Constant	D	V											√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

Function description

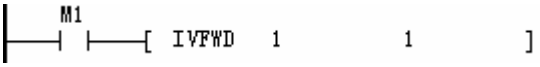
1. Control the drive forward running through communication in the Modbus protocol.

2. This instruction is executed upon the rising edge.

Note

The total number of the instructions for the Modbus communication between PLC and drive does not exceed 128.

Example



LD M1

IVFWD 1 1

Set serial port 1, drive address #1, and control the drive forward running through communication in the Modbus protocol.

After the drive receives the data, it will conduct CRC check, address check and instruction check and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

The error codes in FREQUENCY CONVERTER instruction communication are listed below:

Error code	Description
0x1	Illegal instruction
0x2	Illegal register address
0x3	Data error. The data exceed the range
0x4	Slave operation failure, including the error caused by invalid data within the data range
0x5	Instruction valid, processing. It is used to store data to EEPROM.
0x6	Slave busy, please try again later. It is used to store data to EEPROM.
0x18	Information frame error, including the information length error and check error
0x20	The parameter cannot be modified
0x21	The parameter cannot be modified in the RUN state (only EV3100 supports this function)
0x22	The parameter is protected by password

6.12.3 IVREV: FREQUENCY CONVERTER Reverse Rotation Instruction

LAD: IVREV (S1) (S2)	Applicable to	IVC1
	Influenced flag bit	
IL: IVREV (*S1*) (*S2*)	**Program steps**	**6**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

Function description

1. Control the drive reverse running through communication in the Modbus protocol.
2. This instruction is executed upon the rising edge.

Example

1. Set the serial port 1, drive address #1, and control the drive reverse running through communication in the Modbus protocol.
2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.4 IVDFWD: FREQUENCY CONVERTER Touch Forward Rotation Instruction

LAD: IVDFWD (S1) (S2)	Applicable to	IVC1
	Influenced flag bit	
IL: IVDFWD (*S1*) (*S2*)	**Program steps**	**6**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

Function description

Set the serial port and drive address, and control the drive jog forward running through communication in the Modbus protocol.

Example

Set the serial port 1 and drive address #1, and control the drive jog forward running through communication in the Modbus protocol.

2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.5 IVDREV: FREQUENCY CONVERTER Touch Reverse Rotation Instruction

LAD: [IVDREV (S1) (S2)]	**Applicable to**	**IVC1**
	Influenced flag bit	
IL: IVDREV (*S1*) (*S2*)	**Program steps**	**6**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

Function description

1. Set the serial port and drive address, and control the drive jog reverse running through communication in the Modbus protocol.

2. This instruction is executed upon the rising edge.

Example

LD M1
IVDREV 1 1

1. Set the serial port 1 and drive address #1, and control the drive jog reverse running through communication in the Modbus protocol.

2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.6 IVSTOP: FREQUENCY CONVERTER Stop Instruction

LAD: [IVSTOP (S1) (S2) (S3)]	**Applicable to**	**IVC1**
	Influenced flag bit	
IL: IVSTOP (*S1*) (*S2*) (*S3*)	**Program steps**	**8**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√
S3	WORD	Constant	D	V												√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

S3: drive stop mode.

There are three stop modes: stop mode 0 (stop), stop mode 1 (free stop), stop mode 2 (JOG stop).

Function description

1. Set the serial port and drive address, and control the drive jog reverse running through communication in the Modbus protocol.

2. This instruction is executed upon the rising edge.

Example

LD M1

IVSTOP 1 1 0

1. Set the serial port 1, drive address #1, and the drive stop mode 0 (stop according to the set deceleration time), and control the drive stop through communication in the Modbus protocol.

2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.7 IVFRQ: FREQUENCY CONVERTER Set Frequency Instruction

LAD: IVFRQ (S1) (S2) (S3)	**Applicable to**	**IVC1**
	Influenced flag bit	
IL: IVFRQ (*S1*) (*S2*) (*S3*)	**Program steps**	**8**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	WORD	Constant	D	V											√
S3	WORD	Constant	D	V											√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

S3: frequency of the drive

Function description

1. Set the serial port and drive address, and control the drive operation frequency through communication in the Modbus protocol.
2. This instruction is executed upon the rising edge.

Example

LD M1

IVFRQ 1 1 50

1. Set the serial port 1 and drive address #1, and control the drive operation frequency through communication in the Modbus protocol.
2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.8 IVWRT: FREQUENCY CONVERTER Write Single Register Value Instruction

LAD: IVWRT (S1) (S2) (S3) (S4)	**Applicable to**	**IVC1**
	Influenced flag bit	
IL: IVWRT (*S1*) (*S2*) (*S3*) (*S4*)	**Program steps**	**10**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√
S3	WORD	Constant	D	V												√
S4	WORD	Constant	D	V												√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

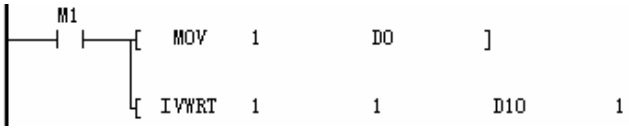
S3: register address

S4: register value

Function description

1. Set the serial port and drive address, input the register address and register value, and the corresponding register will be assigned with the set value through communication in the Modbus protocol.
2. This instruction is executed upon the rising edge.

Example



LD M1

MOV 1 D0

IVWRT 1 1 D10 1

1. Set the serial port 1 and drive address #1, input the register address 1 (digital frequency control) and register value 1 (disable frequency saving upon power-off), and write the value into the corresponding register through communication in the Modbus mode.
2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.9 IVRDST: FREQUENCY CONVERTER Read Status Instruction

LAD: IVRDST (S1) (S2) (S3) (D1)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: IVRDST (*S1*) (*S2*) (*S3*) (*D1*)	**Program steps**	**10**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√
S3	WORD	Constant	D	V												√
D1	WORD	D														√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

S3: status information selection

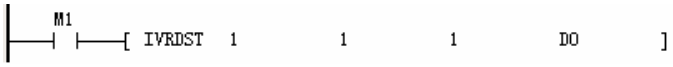
0	Running status word		4	Output voltage
1	Actual operation value in the current main setting		5	Running speed
2	Drive model		6	Operation fault information
3	Output current			

D1: storage address of the returned status information

Function description

1. Read the FREQUENCY CONVERTER status information through communication in the Modbus protocol.
2. This instruction is executed upon the rising edge.

Example



LD M1

IVRDST 1 1 1 D0

1. Set the serial port 1, drive address #1, read status information selection 1 (actual running value in the current main setting) and set D0 as the storage register for the returned status information. Read FREQUENCY CONVERTER status information through communication in the the Modbus protocol.
2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.10 IVRD: FREQUENCY CONVERTER Read Single Register Value Instruction

LAD:	**Applicable to**	**IVC1**
⊣⊢ ⊢[IVRD *(S1)* *(S2)* *(S3)* *(D1)*]	**Influenced flag bit**	
IL: IVRD (*S1*) *(S2)* *(S3)* *(D1)*	**Program steps**	**10**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant														
S2	WORD	Constant	D	V												√
S3	WORD	Constant	D	V												√
D1	WORD	D														√

Operand description

S1: designated communication channel (channel 1)

S2: drive address. Broadcast mode. Broadcast address: 00. Slave address range: 1 ~ 247.

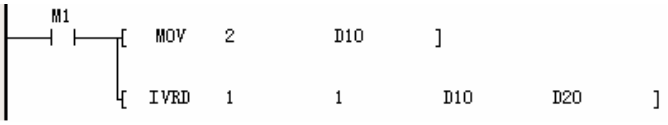
S3: address of the register to read

D1 storage address of the returned value

Function description

1. Read a single FREQUENCY CONVERTER register through communication in the Modbus protocol.
2. This instruction is executed upon the rising edge.

Example



LD M1

MOV 2 D10

IVRD 1 1 D10 D20

1. Set the serial port 1, drive address #1, read register address 2 (initially set frequency of the drive) and set D20 as the storage register for the returned value. Read a single FREQUENCY CONVERTER register through communication in the Modbus protocol.
2. After the drive receives the data, it will conduct CRC check, address check and instruction check, and set the communication completion flag (SM135) after the communication. If there is any error, the error flag (SM136) will be set, and the error details will be recorded in the special register SD139.

6.12.11 XMT: Free-Port Sending (XMT) Instruction

LAD: ┤├─[XMT (S1) (S2) (S3)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: XMT (*S1*) (*S2*) (*S3*)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
S2	WORD	D	V												
S3	INT	Constant	KnX	KnY	KnM	KnS	KnLM		D	SD	C	T	V	Z	

Operand description

S1: designated communication channel. Range: 0, 1

S2: starting address of the data to be sent

S3: number of bytes to be sent

Function description

When the power flow is valid, and the communication conditions are met, the designated data will be sent through the designated channel.

Note

1. Size of communication frame: depending on the element type (D or V) of the communication frame, the ending character of the frame does not exceed D7999 or V63.

2. In case of shutdown, the sending will stop.

Special register

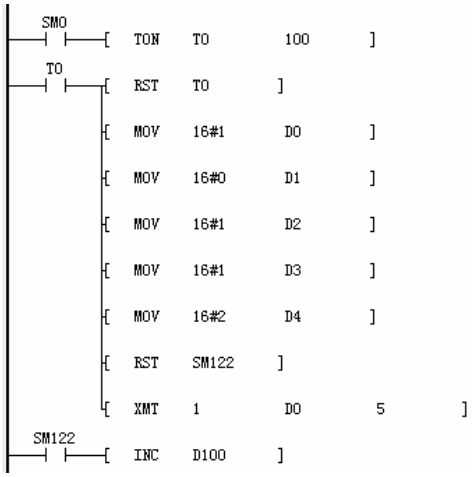
1. SM110/SM120: Sending enabled flag. It will be set when the XMT instruction is used and cleared when the sending is completed. When it is reset, the current sending stops.

2. SM112/SM122: sending completed flag. When it is judged that the sending is completed, the sending completed flag will be set.

3. SM114/SM124: Idle flag. When the serial port has no communication task, it will be set, and it can be used as the checking bit for communication.

4. For detailed examples of the application, please refer to Chapter 10 Communication Function Use Instruction.

Example




```
LD      SM0
TON     T0   100
LD      T0
RST     T0
MOV     16# 1   D0
MOV     16#0   D1
MOV     16#1   D2
MOV     16#1   D3
MOV     16#2   D4
RST     SM122
XMT   1   D0 5
LD      SM122
INC     D1OO
```

In this example, one data frame is sent in every 10s.

The following data will be sent through serial port 1.

01	00	01	01	02

1. Set port 1 in the system block as free port, and then set the baud rate, parity check, data bit and stop bit.

2. Write the data to be sent into the transmission buffer area. For IVC2, only the low bytes of the word element will be sent.

3. Reset the sending completed flag (SM122) before sending the data.

4. When the sending is completed, set the sending completed flag (SM122).

6.12.12 RCV: Free-Port Receiving (RCV) Instruction

LAD: RCV (S1) (D) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: RCV (S1) (D) (S2)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant													
D	WORD	D	V												
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM		D	SD	C	T	V	Z	

Operand description

S1: designated communication channel. Range: 0, 1

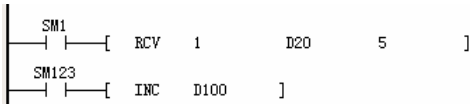
D: starting address for storing the received data

S2: maximum number of received bytes

Function description

When the power flow is valid, and the communication conditions are met, limited amount of data will be received through the designated channel to the designated registers.

Example




```
LD    SM1
RCV   1  D20  5
LD    SM123
INC   D100
```

1. The instruction will be valid continuously as long as the power flow is valid. If you want to receive data only once, you can use a rising edge or special registers that are effective only once, such as SM1, to trigger the instruction.

2. For detailed application examples, refer to *Chapter 10 Using Communication Function*.

Note

Size of communication frame: depending on the element type (D or V) of the communication frame, the ending character of the frame does not exceed D7999 or V63.

The receiving stops upon shutdown.

The value range of S1: 0 and 1

Special register

SM111 (SM121): Receiving enabled flag. It will be set when the RCV instruction is used and cleared when the sending is completed. When it is reset, the current receiving stops.

SM113 (SM123): receiving completed flag. When the receiving is completed, the receiving completed flag will be set.

SM114 (SM124): Idle flag. When the serial port has no communication task, it will be set, and it can be used as the checking bit for communication.

SD111 (SD121): Starting character, which can be set in the system block

SD112 (SD122): Ending character, which can be set in the system block

SD113 (SD123): Character time-out time, i.e. the maximum receiving interval between the two characters, which can be set in the system block

SD114 (SD124): Frame time-out time: the time starting with the power flow and stops at the end of the receiving, which can be set in the system block

SD115 (SD125): receiving completion code. The definition of the data bit is shown as follows:

User end receiving flag	Designated ending word received flag	Maxi. number of characters received flag	Inter-character time-out flag	(Frame) reception time-out flag	Parity check error flag	Reserved
Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bits 6 ~ 15

SD116 (SD126): The characters currently received

SD117 (SD127): The character received previously

6.13 Data Check Instruction

6.13.1 CCITT: Check Instruction

LAD: CCITT (S1) (S2) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: CCITT (S1) (S2) (D)	Program steps	7

Operand	Type	Applicable elements													Offset addressing
S1	WORD								D				V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD								D				V		√

Operand description

S1: the starting element of the data to be checked

S2: the number of the data to be checked. ***S2*** ≥ 0, or the system will report operand error.

D: check result

Function description

1. Conduct CCITT check on the ***S2*** data starting with ***S1***, and assign the result to ***D***.

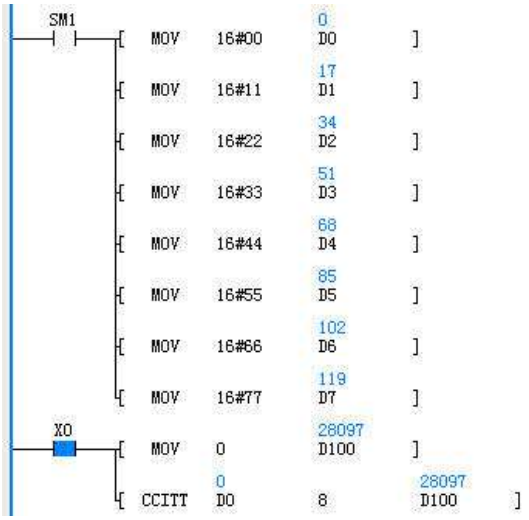
2. The expression for CCITT check algorithm is: X^16+X^12+X^5+1

Note

1. For the system will bring value of ***D*** into the operation each time the instruction is executed, make sure to clear ***D*** before executing the CCITT instruction.

2. The data within the checking data zone starting with ***S2*** are stored in byte mode by default. That is, the high bytes are taken as 0, and the check result has 16 bits.

Example




```
LD      SM1
MOV     16#00 D0
MOV     16#11 D1
MOV     16#22 D2
MOV     16#33 D3
MOV     16#44 D4
MOV     16#55 D5
MOV     16#66 D6
MOV     16#77 D7
LD      X0
MOV     0   D100
CCITT D0 8 D100
```

When X0 is ON, conduct CCITT check on the 8 data starting with D0, and the result is assigned to D100.

6.13.2 CRC16: Check Instruction

LAD: CRC16 (S1) (S2) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: CRC16 (*S1*) (*S2*) (*D*)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD								D				V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD								D				V		√

Operand description

S1: the starting element of the data to be checked

S2: the number of the data to be checked; ***S2*** ≥ 0, or the system will report operand error

D: check result

Function description

1. Conduct CRC16 check on the ***S2*** data starting with ***S1***, and assign the result to ***D*** unit.

2. The expression for CRC16 check algorithm is: X^16+X^15+X^2+1

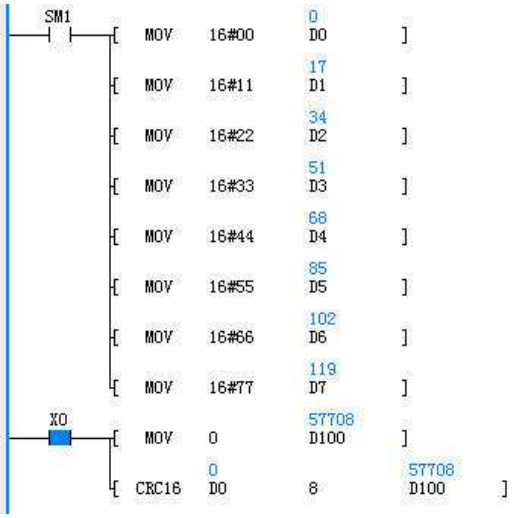
Note

1. For the system will bring value of ***D*** into the operation each time the instruction is executed, make sure to clear ***D*** before executing the CRC16 instruction.

2. The standard Modbus CRC check requires that the D element (checksum) be initialized as 16#FFFF, and the high/low byes (8 high, 8 low) shall be swapped.

3. The data within the checking data zone starting with ***S2*** are stored in byte mode by default. That is, the high bytes will be taken as 0, and the check result has 16 bits.

Example




```
LD      SM1
MOV     16#00   D0
MOV     16#11   D1
MOV     16#22   D2
MOV     16#33   D3
MOV     16#44   D4
MOV     16#55   D5
MOV     16#66   D6
MOV     16#77   D7
LD      X0
MOV     0       D100
CRC16 D0 8 D100
```

When X0 is ON, conduct CRC16 check on the 8 data starting with D0, and the result is assigned to D100.

6.13.3 LRC: Check Instruction

LAD: LRC (S1) (S2) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: LRC (S1) (S2) (D)	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	WORD								D				V		√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	WORD								D				V		√

Operand description

S1: the starting element of the data to be checked

S2: the number of the data to be checked. ***S2*** ≥ 0, or the system will report operand error

D: check result

Function description

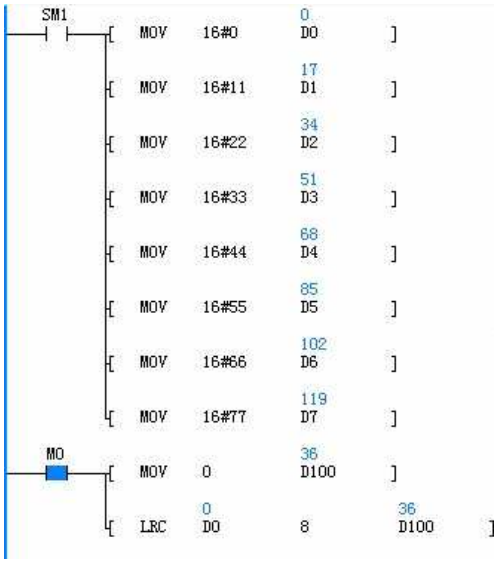
Conduct LRC check on the ***S2*** data starting with the ***S1***, and assign the result to ***D***.

Note

1. For the system will bring value of ***D*** into the operation each time the instruction is executed, make sure to clear ***D*** before executing the LRC instruction.

2. The data within the checking data zone starting with ***S2*** are stored in byte mode by default. That is, the high bytes are taken as 0, and the check result has 8 bits and is stored in the low bytes of ***D***.

Example




```
LD    SM1
MOV   16#00  D0
MOV   16#11  D1
MOV   16#22  D2
MOV   16#33  D3
MOV   16#44  D4
MOV   16#55  D5
MOV   16#66  D6
MOV   16#77  D7
LD    M0
MOV   0      D100
LRC   D0   8 D100
```

When X0 is ON, conduct LRC check on the 8 data starting with D0, and the result is assigned to D100.

6.14 Enhanced Bit Processing Instruction

6.14.1 ZRST: Batch Bit Reset Instruction

LAD: ZRST (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ZRST (D) (S)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	BOOL			Y	M	S	LM				C	T			√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D: destination operand

S: source operand

Function description

When the power flow is valid, reset ***S*** bit-elements starting with ***D***.

Note

1. When a C element is reset, the counting value in it will also be cleared.
2. When a T element is reset, the timing value in it will also be cleared.

Example

```
LD    SM0
ZRST  M10  10
```

When SM0 is ON, the 10 elements M10, M10, M11, M12 ... M19 will be completely cleared.

6.14.2 ZSET: Set Batch Bit Instruction

LAD: ZSET (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ZSET (D) (S)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	BOOL			Y	M	S	LM				C	T			√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

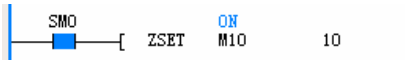
D: destination operand

S: source operand

Function description

When the power flow is valid, set ***S*** bit elements starting with ***D***.

Example




```
LD    SM0
ZSET  M10  10
```

When SM0 is ON, the 10 units M10, M10, M11, M12 … M19, will all be set to 1.

6.14.3 DECO: Decode Instruction

LAD: DECO (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DECO (S) (D)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	WORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: source operand

D: destination operand

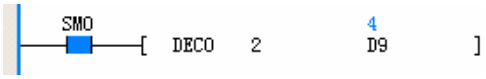
Function description

When the power flow is valid, set bit ***S*** in word element ***D*** to 1, and clear other bits.

Note

1. Range of ***S***: 0 to 15.
2. If ***S*** is outside the range of 0 ~ 15, ***D*** will not be changed when the power flow is valid. Instead, the system will report operand error.

Example




```
LD    SM0
DECO  2  D9
```

When the power flow is valid, bit 2 in D9 will be set as 1, other bits will be cleared.

6.14.4 ENCO: Encode Instruction

LAD: ENCO (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: ENCO (S) (D)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT			KnY	KnM	KnS	KnLM		D	SD	C	T	V	Z	√

Operand description

S: source operand

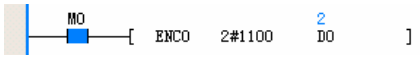
D: destination operand

Function description

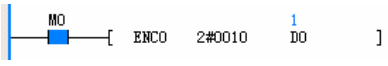
When the power flow is valid, assign the number of the bit whose value is 1 in word element ***S*** to ***D***.

Note

When the value of multiple bits in ***S*** is 1, the smallest bit number will be written into ***D***, as shown in the following figure:



Example




```
LD    M0
ENCO  2#0010  D0
```

When the power flow is valid, operand 1 is 2#0010, bit 1 is 1, hence 1 is written into D0.

6.14.5 BITS: Counting ON Bit In Word Instruction

LAD: BITS (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BITS (S) (D)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
D	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: source operand

D: destination operand

Function description

When the power flow is valid, count how many bits in operand ***S*** is 1, and store the result into ***D***.

Example

```
LD    SM0
BITS  16#F0F0 D1
```

When the power flow is valid, it is counted that there are 8 bits whose value is 1 (ON status) in constant 16#F0F0, so 8 is stored into D1.

6.14.6 DBITS: Counting ON Bit In Double Word Instruction

LAD: DBITS (S) (D)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: DBITS (S) (D)	Program steps	6

Operand	Type	Applicable elements													Offset addressing
S	DWORD	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D	INT			KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S: source operand

D: destination operand

Function description

When the power flow is valid, count how many bits in double word ***S*** is 1, and store the result into ***D***.

Example

```
LD     SM0
DBITS  16#FF0FF  D10
```

When the power flow is valid, it is counted that there are 16 bits whose value is 1 (ON status) in constant 16#FF0FF, so 16 is stored into D10.

6.15 Word Contactor Instruction

6.15.1 BLD: Word Bit Contactor LD Instruction

LAD: BLD (S1) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BLD (S1) (S2)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: source operand

S2: designated bit, 0 ≤ ***S2*** ≤ 15, or system will report operand error

Function description

Use the status of bit ***S2*** in element ***S1*** to drive the following operation.

Example

BLD D0 5
OUT Y0

Use the status of BIT5 (ON) in D0 (1000: 2#0000001111101000) to determine the status of Y0 in the following operation.

6.15.2 BLDI: Word Bit Contactor LDI Instruction

LAD: BLDI (S1) (S2)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BLDI (S1) (S2)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

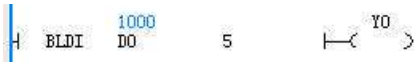
S1: source operand

S2: designated bit. 0 ≤ ***S2*** ≤ 15, or system will report operand error..

Function description

Use the logic NOT of the status of bit ***S2*** in element ***S1*** to drive the following operation.

Example



BLDI D0 5
OUT Y0

Use the logic NOT of the status of BIT5 (ON) in D0 (1000: 2#0000001111101000), which is OFF, to determine the status of Y0 in the following operation.

6.15.3 BAND: Word Bit Contactor AND Instruction

LAD: BLD (S1) (S2)	**Applicable to**	**IVC2 IVC1**
Note: because the logic relationship is visualized in the diagram, the BAND instruction is displayed in LAD as BLD	**Influenced flag bit**	
IL: BAND (S1) (S2)	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: source operand

S2: designated bit. 0 ≤ ***S2*** ≤ 15, or system will report operand error

Function description

Take the status of bit ***S2*** in element ***S1*** and use it in serial connection with other nodes to drive the operation of the following operation.

Example

```
LD    X0
BAND  D0 5
OUT   Y0
```

Take the status of BIT5 (ON) in element D0 (1000: 2#0000001111101000) and use it in serial connection with other nodes (X0: ON) to determine the status of Y0 in the following operation.

6.15.4 BANI: Word Bit Contactor AND Instruction

LAD: BLDI (S1) (S2)	**Applicable to**	**IVC2 IVC1**
Note: because the logic relationship is visualized in the diagram, the BANI instruction is displayed in LAD as BLDI	**Influenced flag bit**	
IL: BANI (S1) (S2)	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: source operand

S2: designated bit, 0 ≤ ***S2*** ≤ 15, or system will report operand error

Function description

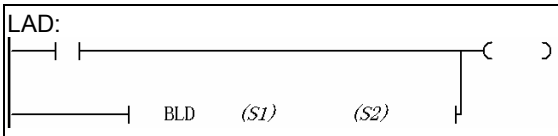
Take the logic NOT of the status of bit ***S2*** in element ***S1*** and use it in serial connection with other nodes to drive the operation of the following instruction.

Example

```
LD    X0
BANI  D0  5
OUT   Y0
```

Take the logic NOT of the status of BIT5 (ON) in element D0 (1000: 2#0000001111101000), which is OFF, and use it in serial connection with other nodes (X0: ON) to determine the status of Y0 in the following operation.

6.15.5 BOR: Word Bit Contactor OR Instruction

LAD:  *Note: because the logic relationship is visualized in the diagram, the BOR instruction is displayed in LAD as BLD*	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: BOR (S1) (S2)	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

S1: source operand

S2: designated bit, 0 ≤ ***S2*** ≤ 15, or system will report operand error

Function description

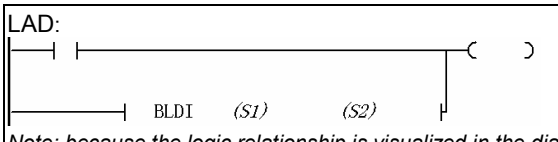
Take the status of bit ***S2*** in element ***S1*** and use it in parallel connection with other nodes to drive the operation of the following instruction.

Example

```
LD    X0
BOR   D0   5
OUT   Y0
```

Take the status of BIT5 (ON) in element D0 (1000: 2#0000001111101000) and use it in parallel connection with other nodes (X0: ON) to determine the status of Y0 in the following operation.

6.15.6 BORI: Word Bit Contactor ORI Instruction

LAD:  *Note: because the logic relationship is visualized in the diagram, the BORI instruction is displayed in LAD as BLDI*	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: BORI (S1) (S2)	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S1	WORD		KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

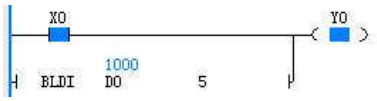
S1: source operand

S2: designated bit, 0 ≤ ***S2*** ≤ 15, or system will report operand error

Function description

Take the logic NOT of the status of bit ***S2*** in element ***S1*** and use it in parallel connection with other nodes to drive the operation of the following segment.

Example




```
LD    X0
BORI  D0   5
OUT   Y0
```

Take the logic NOT of the status of BIT5 (ON) in element D0 (1000: 2#0000001111101000), which is OFF, and use it in parallel connection with other nodes (X0: ON) to determine the status of Y0 in the following operation.

6.15.7 BOUT: Word Bit Coil Output Instruction

LAD: BOUT (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BOUT (D) (S)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

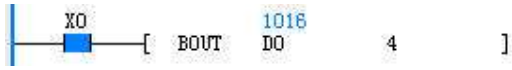
S1: source operand

S2: designated bit. 0 ≤ ***S2*** ≤ 15, or system will report operand error.

Function description

Assign the current power flow status to bit ***S*** of element ***D***.

Example




```
LD   X0
BOUT D0 4
```

Assign the current power flow status (X0: ON) to BIT4 ofelement D0 (1000: 2#0000001111101000). After the execution, D0 = 1016 (2#0000001111111000).

6.15.8 BSET: Word Bit Coil Set Instruction

LAD: BSET (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BSET (D) (S)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

D: destination operand

S2: designated bit. 0 ≤ ***S2*** ≤ 15, or system will report operand error.

Function description

Set bit ***S*** of element ***D***.

Example

```
LD   X0
BSET D0 8
```

When the power flow is valid, set BIT15 of element D0 (1000: 2#0000001111101000). After the execution, D0 = 33768 (2#1000001111101000).

6.15.9 BRST: Word Bit Coil Reset Instruction

LAD: BRST (D) (S)	Applicable to	IVC2 IVC1
	Influenced flag bit	
IL: BRST (D) (S)	Program steps	5

Operand	Type	Applicable elements													Offset addressing
D	WORD			KnY	KnM	KnS	KnLM		D		C	T	V	Z	√
S	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

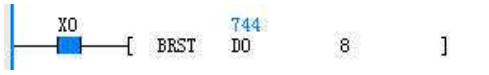
D: destination operand

S2: designated bit. 0 ≤ ***S2*** ≤ 15, or system will report operand error.

Function description

Reset bit ***S*** of element ***D***.

Example




```
LD   X0
BRST D0 8
```

When the power flow is valid, reset BIT8 of element D0 (1000: 2#0000001111101000). After the execution, D0 = 744 (2#0000001011101000).

6.16 Compare Contactor Instrucitons

6.16.1 Compare Integer LD (=，<，>，<>，>=，<=) Instrucitons

LAD: =　(S1)　(S2) <　(S1)　(S2) >　(S1)　(S2) <>　(S1)　(S2) >=　(S1)　(S2) <=　(S1)　(S2)	**Applicable to**	**IVC2　IVC1**
	Influenced flag bit	
IL:　LD=　(*S1*)　(*S2*) **LD<　(*S1*)　(*S2*)** **LD>　(*S1*)　(*S2*)** **LD<>　(*S1*)　(*S2*)** **LD>=　(*S1*)　(*S2*)** **LD<=　(*S1*)　(*S2*)**	**Program steps**	**5**

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S2	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

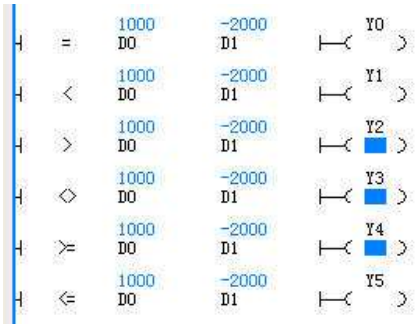
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Conduct BIN comparison on elements ***S1*** and ***S2***, and use the comparison result to drive the following operation.

Example




```
LD=   D0 D1
OUT   Y0
LD<   D0 D1
OUT   Y1
LD>   D0 D1
OUT   2
LD<>  D0 D1
OUT   Y3
LD>=  D0 D1
OUT   Y4
LD<=  D0 D1
OUT   Y5
```

Conduct BIN comparison on the data of D0 and D1, and the comparison result is used to determine the output status of the following element.

6.16.2 Compare Integer AND (=，<，>，<>，>=，<=) Instruction

LAD: = (S1) (S2) < (S1) (S2) > (S1) (S2) <> (S1) (S2) >= (S1) (S2) <= (S1) (S2)	**Applicable to** IVC2 IVC1
	Influenced flag bit
IL: **AND= (*S1*) (*S2*)** **AND< (*S1*) (*S2*)** **AND> (*S1*) (*S2*)** **AND<> (*S1*) (*S2*)** **AND>= (*S1*) (*S2*)** **AND<= (*S1*) (*S2*)**	**Program steps** 5

Operand	Type	Applicable elements													Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z	√

Operand description

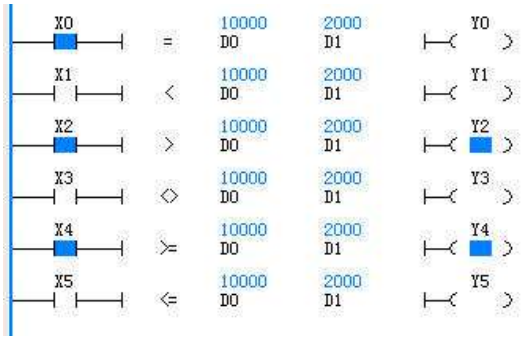
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Conduct BIN comparison on elements ***S1*** and ***S2***, and use the comparison result in serial connection with other nodes to drive the following operation.

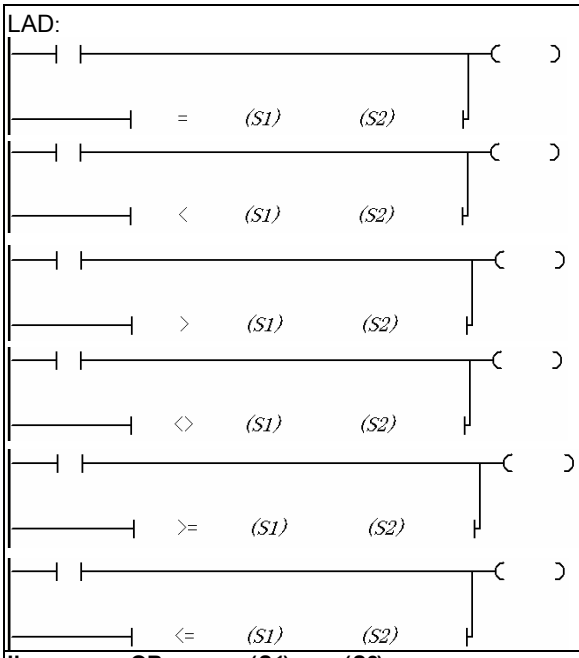
Example




```
LD      X0
AND=    D0 D1
OUT     Y0
LD      X1
AND<    D0 D1
OUT     Y1
LD      X2
AND>    D0 D1
OUT     Y2
LD      X3
AND<>   D0 D1
OUT     Y3
LD      X4
AND>=   D0 D1
OUT     Y4
LD      X5
AND<=   D0 D1
OUT     Y5
```

Conduct BIN comparison on the data of D1 and D2, and use the comparison result in serial connection with other nodes to determine the output status of the following element.

6.16.3 Compare Integer OR (=, <, >, <>, >=, <=) Instruction

LAD:  	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: **OR= (*S1*) (*S2*)** **OR< (*S1*) (*S2*)** **OR> (*S1*) (*S2*)** **OR<> (*S1*) (*S2*)** **OR>= (*S1*) (*S2*)** **OR<= (*S1*) (*S2*)**	**Program steps**	**5**

Operand	Type	Applicable elements														Offset addressing
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√
S1	INT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C	T	V	Z		√

Operand description

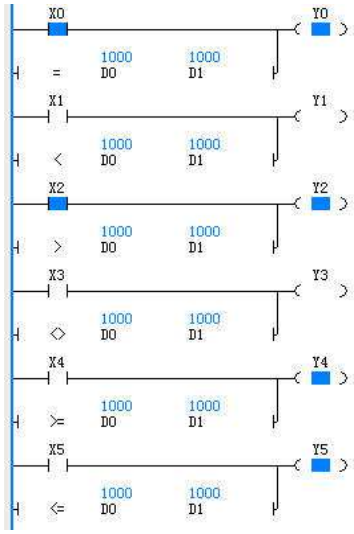
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result in parallel connection with other nodes to drive the following operation.

Example




```
LD      X0
OR=     D0 D1
OUT     Y0
LD      X1
OR<     D0 D1
OUT     Y1
LD      X2
OR<>    D0 D1
OUT     Y2
LD      X3
OR>=    D0 D2
OUT     Y3
LD      X4
OR>=    D0 D1
OUT     Y4
LD      X5
OR<=    D0 D1
OUT     Y5
```

Compare elements D0 and D1, and use the comparison result in parallel connection with other nodes to determine the output status of the following element.

6.16.4 Compare Double Integer LDD (=, <, >, <>, >=, <=) Instruction

LAD:		
D= (S1) (S2) ⊣⊢	**Applicable to**	**IVC2 IVC1**
D< (S1) (S2) ⊣⊢		
D> (S1) (S2) ⊣⊢		
D<> (S1) (S2) ⊣⊢	**Influenced flag bit**	
D>= (S1) (S2) ⊣⊢		
D<= (S1) (S2) ⊣⊢		
IL: **LDD= (*S1*) (*S2*)** **LDD< (*S1*) (*S2*)** **LDD> (*S1*) (*S2*)** **LDD<> (*S1*) (*S2*)** **LDD>= (*S1*) (*S2*)** **LDD<= (*S1*) (*S2*)**	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√

Operand description

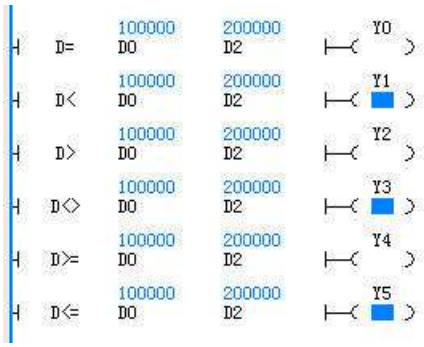
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result to drive the following operation.

Example




```
LD= D0 D2
OUT Y0
LD<  D0 D2
OUT  Y1
LD<> D0 D2
OUT  Y2
LD>= D0 D2
OUT  Y3
LD>= D0 D2
OUT  Y4
LD<=D0 D2
OUT Y5
```

Compare (D0, D1) and (D2,D3), and use the comparison result to determine the output status of the following element.

6.16.5 Compare Double Integer ANDD (=，<，>，<>，>=，<=) Instruction

LAD: D= (S1) (S2) D< (S1) (S2) D> (S1) (S2) D<> (S1) (S2) D>= (S1) (S2) D<= (S1) (S2)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: **ANDD= (*S1*) (*S2*)** **ANDD< (*S1*) (*S2*)** **ANDD> (*S1*) (*S2*)** **ANDD<> (*S1*) (*S2*)** **ANDD>= (*S1*) (*S2*)** **ANDD<= (*S1*) (*S2*)**	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√

Operand description

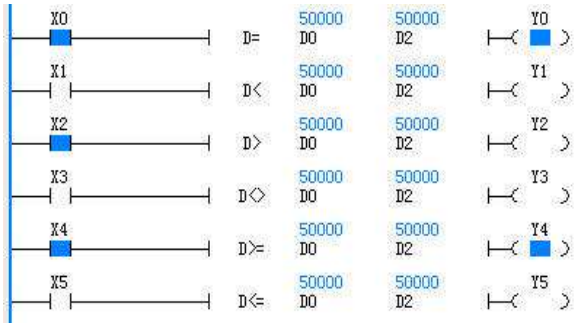
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result in serial connection with other nodes to drive the following operation.

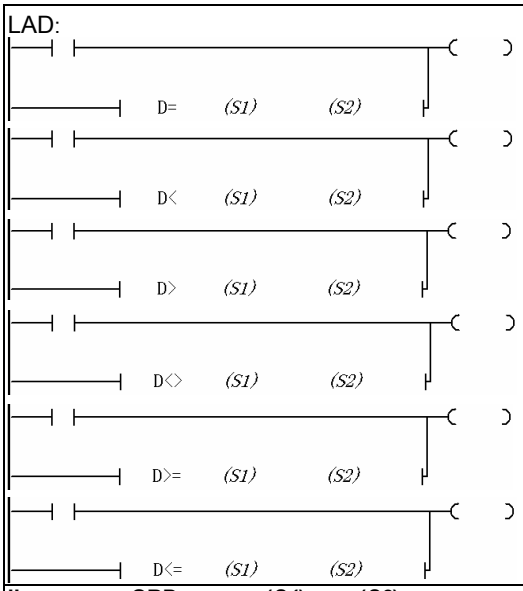
Example




```
LD      X0
LDD=    D0 D2
OUT     Y0
LD      X1
LDD<    D0 D2
OUT     Y1
LD      X2
LDD<>   D0 D2
OUT     Y2
LD      X3
LDD<>   D0 D2
OUT     Y3
LD      X4
LDD>=   D0 D2
OUT     Y4
LD      X5
LDD<=   D0 D2
OUT     Y5
```

Compare (D0, D1) and (D2,D3), and use the comparison result in serial connection with other nodes to determine the output status of the following element.

6.16.6 Compare Double Integer ORD (=, <, >, <>, >=, <=) Instruction

LAD:  	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	
IL: **ORD=** **(*S1*)** **(*S2*)** **ORD<** **(*S1*)** **(*S2*)** **ORD>** **(*S1*)** **(*S2*)** **ORD<>** **(*S1*)** **(*S2*)** **ORD>=** **(*S1*)** **(*S2*)** **ORD<=** **(*S1*)** **(*S2*)**	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√

Operand description

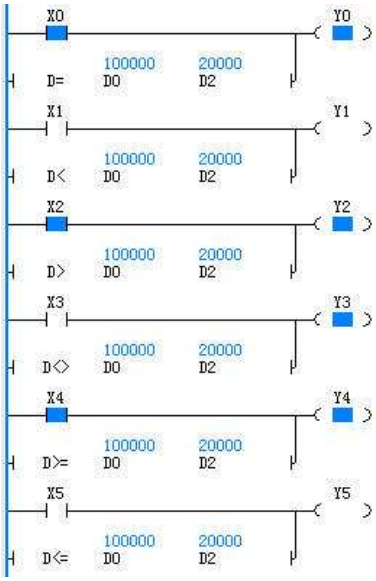
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result in parallel connection with other nodes to drive the following operation.

Example




```
LD      X0
ORD=    D0 D2
OUT     Y0
LD      X1
ORD<    D0 D2
OUT     Y1
LD      X2
ORD<>   D0 D2
OUT     Y2
LD      X3
ORD>=   D0 D2
OUT     Y3
LD      X4
ORD>=   D0 D2
OUT     Y4
LD      X5
ORD<=   D0 D2
OUT     Y5
```

Compare (D0, D1) and (D2,D3), and use the comparison result in parallel connection with other nodes to determine the output status of the following element.

6.16.7 Compare Floating Point Number LDR Instruction

LAD:	Applicable to	IVC2 IVC1
R= (S1) (S2) R< (S1) (S2) R> (S1) (S2) R<> (S1) (S2) R>= (S1) (S2) R<= (S1) (S2)	Influenced flag bit	
IL: **LDR= (*S1*) (*S2*)** **LDR< (*S1*) (*S2*)** **LDR> (*S1*) (*S2*)** **LDR<> (*S1*) (*S2*)** **LDR>= (*S1*) (*S2*)** **LDR<= (*S1*) (*S2*)**	**Program steps**	**7**

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	RAEL	Constant							D				V		√

Operand description

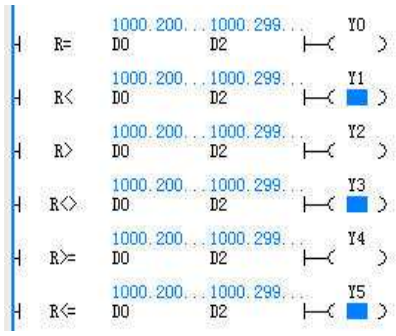
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result to drive the following operation.

Example




```
LDR=    D0 D2
OUT     Y0
LDR<    D0 D2
OUT     Y1
LDR>    D0 D2
OUT     Y2
LDR<>   D0 D2
OUT     Y3
LDR>=   D0 D2
OUT     Y4
LDR<=   D0 D2
OUT     Y5
```

Compare (D0, D1) and (D2,D3), and use the comparison result determine the output status of the following element.

6.16.8 Compare Floating Point Number ANDR Instruction

LAD: R= (S1) (S2) R< (S1) (S2) R> (S1) (S2) R<> (S1) (S2) R>= (S1) (S2) R<= (S1) (S2)	**Applicable to** IVC2 IVC1
	Influenced flag bit
IL: **ANDR= (S1) (S2)** **ANDR< (S1) (S2)** **ANDR> (S1) (S2)** **ANDR<> (S1) (S2)** **ANDR>= (S1) (S2)** **ANDR<= (S1) (S2)**	**Program steps** 7

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√

Operand description

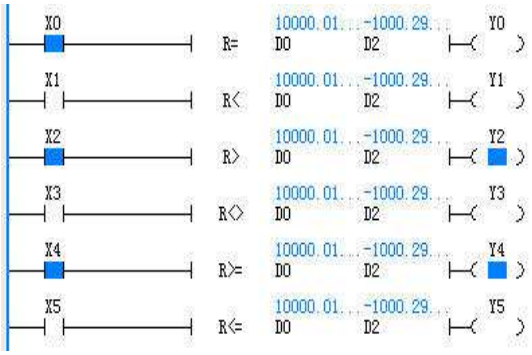
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result in serial connection with other nodes to drive the following operation.

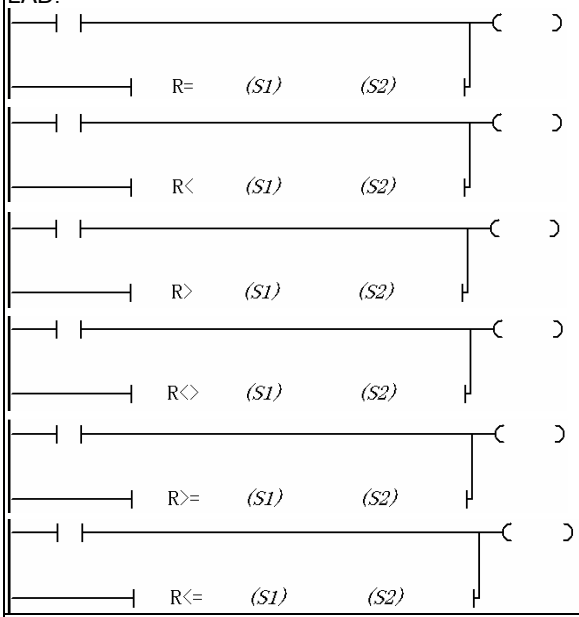
Example




```
LD      X0
ANDR=   D0 D2
OUT     Y0
LD      X1
ANDR<   D0 D2
OUT     Y1
LD      X2
ANDR<>  D0 D2
OUT     Y2
LD      X3
ANDR<>  Y3
LD      X4
ANDR>=  D0 D2
OUT     Y4
LD      X5
ANDR<=  D0 D2
OUT     Y5
```

Compare (D0, D1) and (D2,D3), and use the comparison result in serial connection with other nodes to determine the output status of the following element.

6.16.9 Compare Floating Point Number ORR Instruction

<table>
<tr><td>LAD:
 
</td><td>Applicable to</td><td>IVC2 IVC1</td></tr>
<tr><td></td><td>Influenced flag bit</td><td></td></tr>
<tr><td>IL: ORR= (S1) (S2)
ORR< (S1) (S2)
ORR> (S1) (S2)
ORR<> (S1) (S2)
ORR>= (S1) (S2)
ORR<= (S1) (S2)</td><td>Program steps</td><td>7</td></tr>
</table>

Operand	Type	Applicable elements													Offset addressing
S1	REAL	Constant							D				V		√
S2	REAL	Constant							D				V		√

Operand description

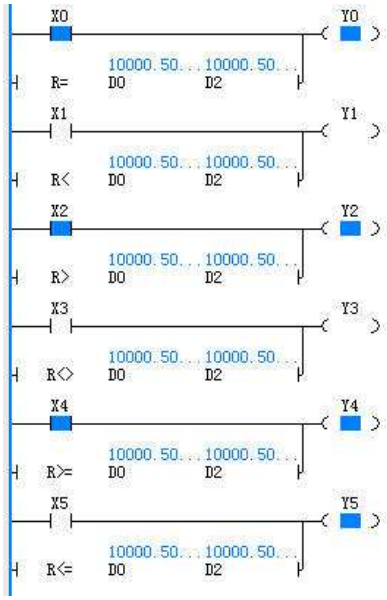
S1: comparison parameter 1

S2: comparison parameter 2

Function description

Compare elements ***S1*** and ***S2***, and use the comparison result in parallel connection with other nodes to drive the following operation.

Example




```
LD      X0
ORR=    D0 D2
OUT     Y0
LD      X1
ORR<    D0 D2
OUT     Y1
LD      X2
ORR>    D0 D2
OUT     Y2
LD      X3
ORR<>   D0 D2
OUT     Y3
LD      X4
ORR>=   D0 D2
OUT     Y4
LD      X5
ORR<=   D0 D2
OUT     Y5
```

Compare (D0, D1) and (D2, D3), and use the comparison result in parallel connection with other nodes to determine the output status of the following element.

6.17 Locating Instructions

6.17.1 Setting Up An Absolute Position System

The absolute position system obtains the absolute position data of the servo motor by detecting the the current position and the total cycle number of the motor PG. In this way, we can set up an absolute coordinates system of the mechanical position. The following figure is a schematic diagram of an absolute position system:

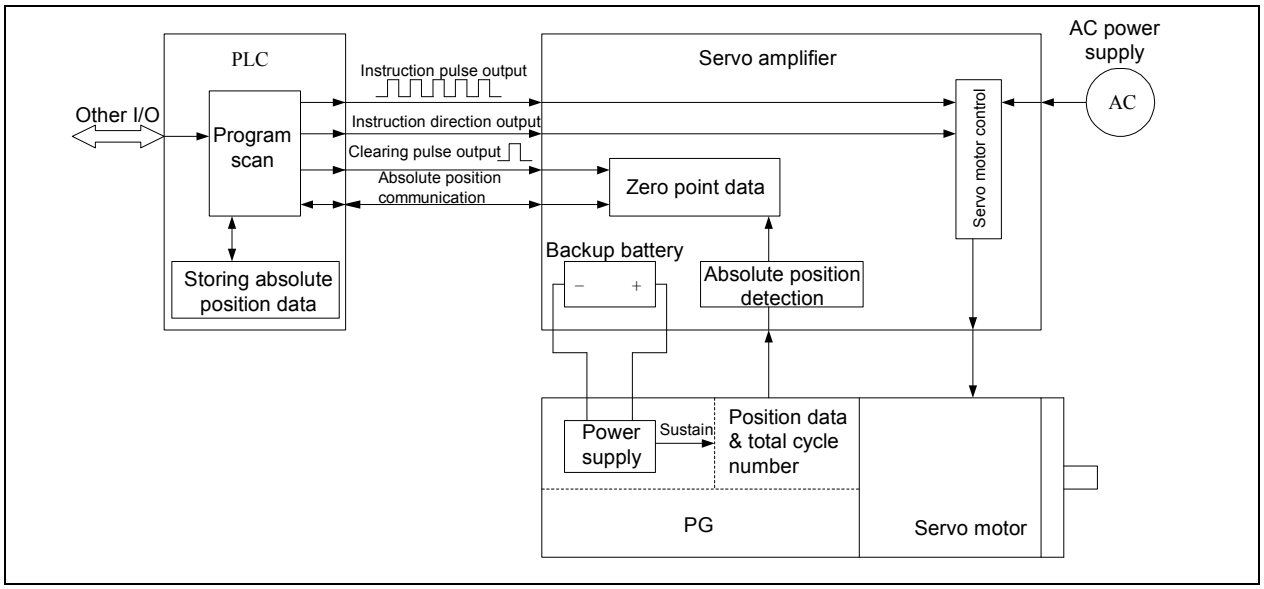


Figure 6-1 Absolute position system

As shown in the figure, the PG of an absolute position system is special because it is battery backed, which protects its position data and total cycle number upon power failure. That means even after a power failure, the servo amplifier can obtain the current absolute position data after power on.

After power on, the PLC can obtain absolute position data from the servo amplifier through communication. PLC can then use its locating instructions to control the servo amplifier and motor to realize precision positioning over mechanical parts, and automatically refreshes its absolute position data. In this way, a positioning system based on absolute position coordinates can be set up.

6.17.2 Overview Of Locating Instructions For IVC Series PLC

The IVC series small PLC provides locating instructions, including ZRN, PLSV, DRVI, DRVA and ABS, to control various servo amplifiers and servo motors in the absolute position system. The absolute locating data is available through the corresponding servo amplifier.

6.17.3 Mechanical Diagram Of Absolute Position System

The mechanical diagram of the absolute position system that is based on the locating instructions of IVC series small PLC is shown in the following figure.

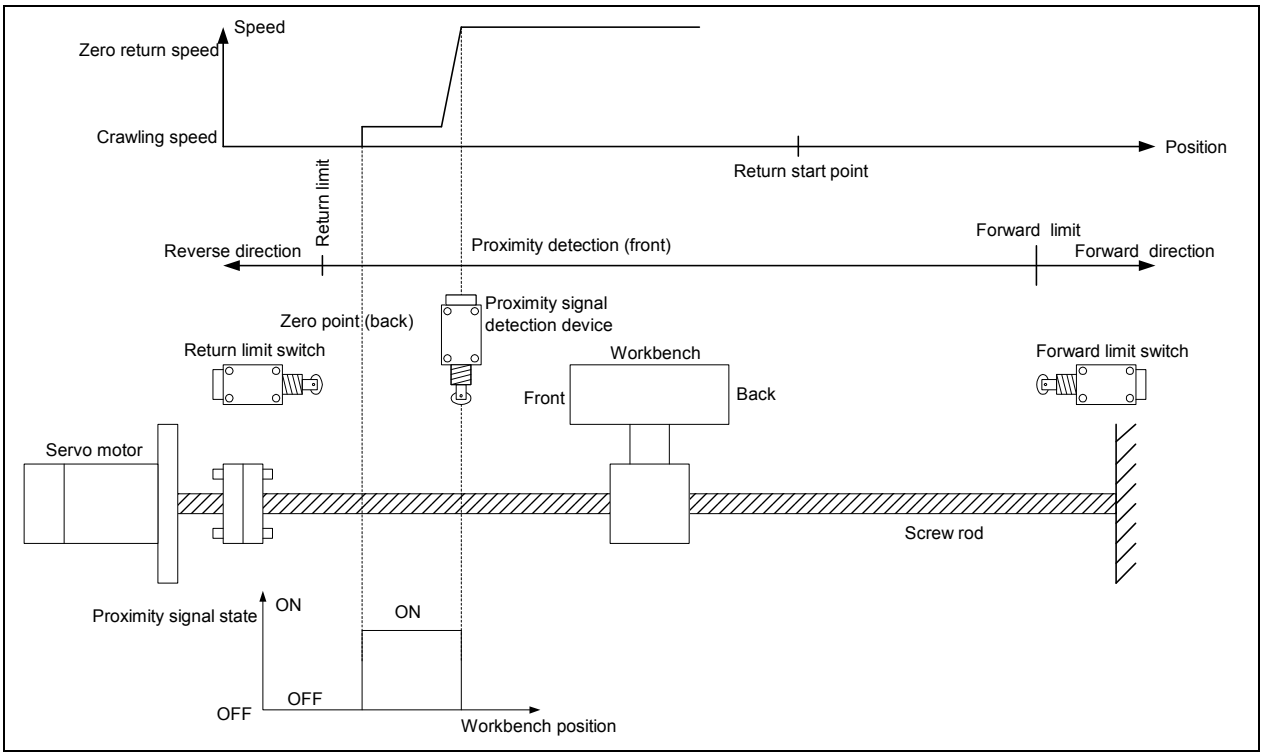


Figure 6-2 Absolute position system based on locating instructions of IVC series small PLC

In this system, the servo motor drives the screw rod, which in turn drives the workbench. The location of the workbench in the stroke is detected by an absolute PG. During the zero return, the servo motor will decelerate to the crowling speed when the proximity sensor detects the fore-end of the workbench. When the proximity sensor detects the rear-end of the workbench, it sends the zero returned signal to the PLC to stop high speed pulse output. Note that the forward limit switch and backward limit switch are a must. Because the zero return instruction (ZRN) is incapable of auto-searching the proximity signal, the zero return operation must start earlier than where the proximity sensor is located. You can jog-adjust the position of the workbench through designing and programming.

6.17.4 Points To Note For Using Locating instructions ZRN, PLSV, DRVI And DRVA

Transistor output

IVC series small PLC with transistor output must be used.

Requirements of locating instructions during programming

The locating instructions can be used repeatedly in the program. However, note that:

1. One high speed pulse output point (Y0 or Y1) can be driven only by one locating instruction (or high speed instruction) at any time.

2. After the power flow of one locating instruction turns OFF, it cannot turn ON before the next PLC scan cycle.

Notes on using instructions PLSY, PLSR and PLS at the same time

From the functional perspective, it is recommended to use DRVI in stead of high speed pulse output instructions PLSY, PLSR and PLS, because the DRVI instruction can update the absolute position registers SD80 ~ SD83 automatically.

The registers SD80 ~ SD83 can be used to store the present absolute position after the locating instruction is used. Their values are based on the change of registers SD50 ~ SD53 and the control signal direction when the locating instruction is executed. In this way, SD80 ~ SD83 and SD50 ~ SD53 are inter-related. Do not write SD50 ~ SD53 when locating instructions are being executed, or SD80 ~ SD83 will be messed up.

If it is necessary to use locating instructions and high speed pulse output instructions PLSY, PLSR or PLS at the same time, do write a PLC program so that registers SD80 ~ SD83 can be updated correctly.

Limits on the actual output frequency of locating instructions

The minimum frequency of the actual output pulse upon the execution of locating instructions is limited by the following formula:

$$F_{\min\_acc} = \sqrt{\frac{F_{\max} \times 500}{T}}$$

Where $F_{\max}$ is the highest frequency set in SD85 or SD86, T is the acceleration or deceleration time (unit: ms) set in SD87, and the result $F_{\min\_acc}$ is the minimum output frequency.

If the output frequency specified in the locating instruction is F, the possible three output frequencies are:

- No output, when F is smaller than the minimum frequency or bigger than $F_{\max}$
- $F_{\min\_acc}$ (when F < $F_{\min\_acc}$)
- F (when $F_{\min\_acc}$ ≤ F ≤ $F_{\max}$)

6.17.5 Notes On Servo Amplifiers

Set the pulse input mode of the servo amplifier or stepping drivers like this:

- Pulse train input mode: instruction pulse + instruction direction
- Pulse string logic: negative logic (effective on the trailing edge)

6.17.6 Special Elements Related To Locating instructions

Monitors of high speed pulse output channels

Addr.	Name	Function	R/W	IVC2	IVC1	Remark
SM80	Y0 high speed pulse output control	Y0 high speed pulse output stop instruction	R/W	√	√	Setting SM80 and SM81 respectively can disable the high speed pulse output of Y0 and Y1, and resetting SM80 & SM81 enables the function
SM81	Y1 high speed pulse output control	Y1 high speed pulse output stop instruction	R/W	√	√	
SM82	Y0 high speed pulse output monitor	Y0 high speed pulse output mointor (ON: busy. OFF: ready)	R	√	√	SM82 and SM83 can be used to monitor the state of high speed output channel
SM83	Y1 high speed pulse output monitor	Y1 high speed pulse output monitor (ON: busy. OFF: ready)	R	√	√	
SM85	Clearing function enabled	Output of CLR signal for ZRN instruction enabled	R/W		√	When SM85 is set, the CLR signals for high speed outputs Y0 and Y1 are output through Y2 and Y3 respectively

Note

If SM85 is set, when the ZRN instruction is executed, Y2 or Y3 will output a CLR pulse with the width of 20ms longer than the scan cycle. If Y2 or Y3 is used for other purposes, you should reset SM85 to disable that function.

Special data registers for locating instructions

Addr.	Name	R/W	IVC2	IVC1	Initial value	Remark
SD80	Current value of Y0 output locating instruction (MSB)	R/W	V1.29	√	0	SD80 ~ SD83 are used to store and calculate the absolute position. Their values are based on SD50 ~ SD53 and the control signal direction when the locating instruction is executed. Whenever the PLC is ON and the absolute position data is read from the servo amplifier, put the position data (32-bit integer) into SD80 or SD82
SD81	The current value of Y0 output locating instruction (LSB)	R/W	V1.29	√		
SD82	The current value of Y1 output locating instruction (MSB)	R/W	V1.29	√	0	
SD83	The current value of Y1 output locating instruction (LSB)	R/W	V1.29	√		
SD84	Basic frequency of executing of instructions ZRN, DRVI and DRVA	R/W	V1.29	√	5000	1. You can change SD84, SD85, SD86 and SD87 according to the actual need. However, do not make the change during the execution of locating instruction, or the instruction may fail. 2. The SD84 basic frequency must be smaller than 1/10 of SD85 highest frequency, or SD84 will be set automatically as 1/10 of highest frequency. When the frequency in a locating instruction is smaller than the basic frequency or higher than the highest frequency, no pulse will be output
SD85	Highest frequency of executing of instructions ZRN, DRVI and DRVA (MSB)	R/W	V1.29	√	100000	
SD86	Highest frequency of executing of instructions ZRN, DRVI and DRVA (LSB)	R/W	V1.29	√		
SD87	Acceleration or deceleration time of executing of instructions ZRN, DRVI and DRVA	R/W	V1.29	√	1000	

6.17.7 ZRN: Regress To Origin Instruction

LAD: ZRN (S1) (S2) (S3) (D)	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Zero, carry, borrow**
IL: ZRN *(S1)* *(S2)* *(S3)* *(D)*	**Program steps**	**11**

Operand	Type	Applicable elements														Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V			√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V			√
S3	BOOL		X	Y	M	S										
D1	BOOL			Y												

Operand description

S1: zero return speed, specifying the zero return start speed

32-bit instruction: 10 ~ 100,000 (Hz)

S2: crawling speed, specifying the relatively low speed when the proximity signal is ON

S3: Proximity signal, specifying the X point for inputting proximity signal

If a non-X element is specified, the position offset of the zero point will increase due to the influence of the PLC calculation cycle.

D: starting address (Y0 or Y1) of the high speed pulse output

Function description

When SM85 clearing function is enabled, the CLR signals for high speed pulse outputs Y0 and Y1 are output through Y2 and Y3 respectively. When SM85 is set, the CLR signals will be output to the servo amplifier through Y2 and Y3.

Note

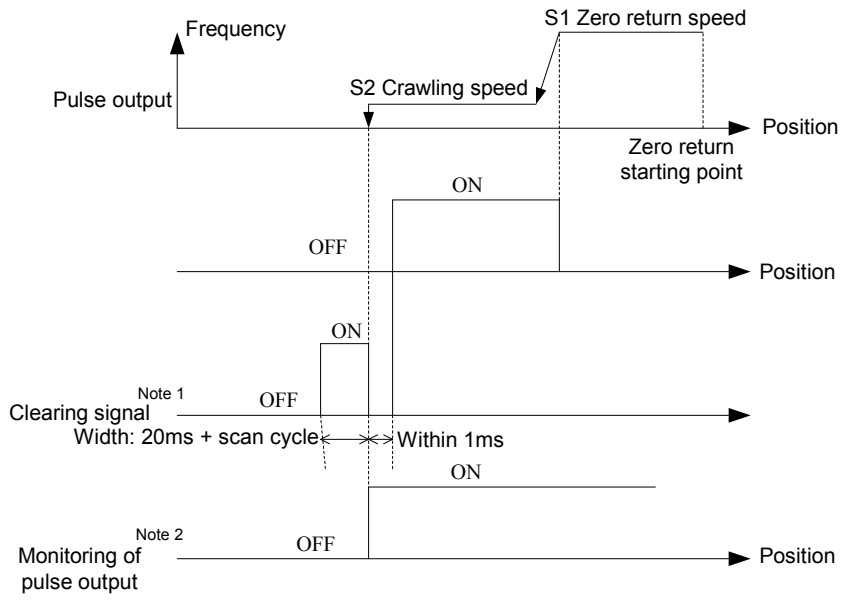
1. Because the ZRN instruction is incapable of searching the proximity signal automatically, the zero return operation must start earlier than where the proximity sensor is located.

2. During the return to zero process, the value of the current value register will decrease.

3. Pay attention to the configuration of SD84 ~ SD87 when using this instruction.

4. When the instruction input frequency is smaller than SD84, there will be no high speed output at Y0 or Y1. When the instruction input frequency is bigger than SD85 or SD86, the output will be abnormal.

Time sequence chart



Note 1: When SM85 is set, the clearing function is valid
Note 2: SM82 & SM83 are the monitors of Y0 & Y1 pulse outputs respectively

6.17.8 PLSV: Variable Speed Pulse Output Instruction

LAD: ⊣⊢ ⊢[PLSV (S) (D1) (D2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Zero, Carry, Borrow**
IL: PLSV *(S)* *(D1)* *(D2)*	**Program steps**	**8**

Operand	Type	Applicable elements													Offset addressing
S	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D1	BOOL			Y											
D2	BOOL			Y	M	S									

Operand description

S: output pulse frequency (Hz)

32-bit instruction: 10 ~ 100,000(Hz), -1 ~ -100,000(Hz)

D1: high speed pulse output starting address (Y0 or Y1)

D2: rotating direction signal output starting address. Its state is determined by ***S***:

- When ***S*** is positive: ***D2*** is ON
- When ***S*** is negative: ***D2*** is OFF

Function description

1. You can change ***S*** even in the state of outputing high speed pulses

2. Because there will be no acceleration or deceleration during the start & stop, if buffer is needed during the start or stop, it is recommended to use the RAMP instruction to change the value of pulse frequency ***S.***

3. In the process of high speed pulse output, when the power flow driven by the instruction turns OFF, the output will stop without deceleration.

4. If the corresponding high speed pulse output monitor (SM82 or SM83) is ON, the power flow driven by the instruction will not be driven by the instruction again after the power flow turns OFF.

5. The direction is determined by the positive or negative nature of ***S***.

Note

1. Pay attention to the instruction driven time

2. The high speed I/O instructions, PLS instruction and locating instructions can use Y0 or Y1 to output high speed pulses. However, take care not to use more than one such instructions on Y0 or Y1 at one time.

6.17.9 DRVI: Relative Position Control Instruction

LAD: ⊣⊢ ⊢[DRVI (S1) (S2) (D1) (D2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Zero, Carry, Borrow**
IL: DRVI *(S1) (S2) (D1) (D2)*	**Program steps**	**11**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D1	BOOL			Y											
D2	BOOL			Y	M	S									

Operand description

S1: output pulse number (relatively specified)

32-bit instruction: -999999 ~ +999999

S2: output pulse frequency (Hz)

32-bit instruction: 10 ~ 100000 (Hz)

D1: high speed pulse output starting address (Y0 or Y1)

D2: rotating direction signal output starting address. Its state is determined by ***S1***:

- When ***S1*** is positive: ***D2*** is ON
- When ***S1*** is negative: ***D2*** is OFF

Function description

1. ***S1*** is stored in the following current registers:
   - Y0 output: SD80, SD81 (32-bit)
   - Y1 output: SD82, SD83 (32-bit)
2. When ***D2*** is OFF, the value of the current value register will decrease.
3. The rotating direction is determined by the positive or negative nature of ***S1***.
4. Changing the operands during the execution of the instruction will not take effect until the next cycle when the instruction is executed again.
5. During the execution of the instruction, the output will decelerate to stop when the driven contact turns OFF. The exection completion flag SM will not act then.
6. If the corresponding high speed pulse output control (SM80 or SM81) is ON, the contact driven by the instruction will not be driven by the instruction again after the contact turns OFF.

Note

1. Pay attention to the configuration of SD84 ~ SD87 when using this instruction
2. When the instruction input frequency is smaller than SD84, there will be no high speed output at Y0 or Y1. When the instruction input frequency is bigger than SD85 or SD86, the output will be abnormal.

6.17.10 DRVA: Control Absolute Position Instruction

LAD: ⊣⊢ ⊢[DRVA (S1) (S2) (D1) (D2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Zero, carry, borrow**
IL: DRVA *(S1)* *(S2)* *(D1)* *(D2)*	**Program steps**	**11**

Operand	Type	Applicable elements													Offset addressing
S1	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
S2	DINT	Constant	KnX	KnY	KnM	KnS	KnLM	KnSM	D	SD	C		V		√
D1	BOOL			Y											
D2	BOOL			Y	M	S									

Operand description

S1: targe position (absolutely specified)

32-bit instruction: -999999 ~ +999999

S2: output pulse frequency (Hz)

32-bit instruction: 10 ~ 100000 (Hz)

D1: high speed pulse output starting address (Y0 or Y1). The PLC output must be transistor output

D2: rotating direction signal output starting address. Its state is determined by ***S1***:

- When ***S1*** is positive: ***D2*** is ON
- When ***S1*** is negative: ***D2*** is OFF

Function description

1. ***S1*** is stored in the following registers:
   - Y0 output: SD80, SD81 (32-bit)
   - Y1 output: SD82, SD83 (32-bit)
2. When ***D2*** is OFF, the value of the current value register will decrease.
3. The rotating direction is determined by the positive or negative nature of ***S1***.
4. Changing the operands during the execution of the instruction will not take effect until the next cycle when the instruction is executed again.
5. During the execution of the instruction, the output will decelerate to stop when the driven contact turns OFF. The exection completion flag SM will not act then.
6. If the corresponding high speed pulse output control (SM80 or SM81) is ON, the contact driven by the instruction will not be driven by the instruction again after the contact turns OFF.

Note

1. Pay attention to the configuration of SD84 ~ SD87 when using this instruction
2. When the instruction input frequency is smaller than SD84, there will be no high speed output at Y0 or Y1. When the instruction input frequency is higher than SD85 or SD86, the output will be abnormal.

6.17.11 ABS: Read Current Value Instruction

LAD: ⊣⊢ ⊢[ABS (S) (D1) (D2)]	**Applicable to**	**IVC2 IVC1**
	Influenced flag bit	**Zero, carry, borrow**
IL: ABS *(S)* *(D1)* *(D2)*	**Program steps**	**8**

Operand	Type	Applicable elements													Offset addressing
S	BOOL	X	Y	M	S										
D1	BOOL		Y	M	S										
D2	DINT		KnY	KnM	KnS					D	SD	C			√

Operand description

S: the input point from servo.

The input points occupies three consecutive Xs (***S***, ***S*** + 1 and ***S*** + 2) or other bit elements.

D1: output points to servo.

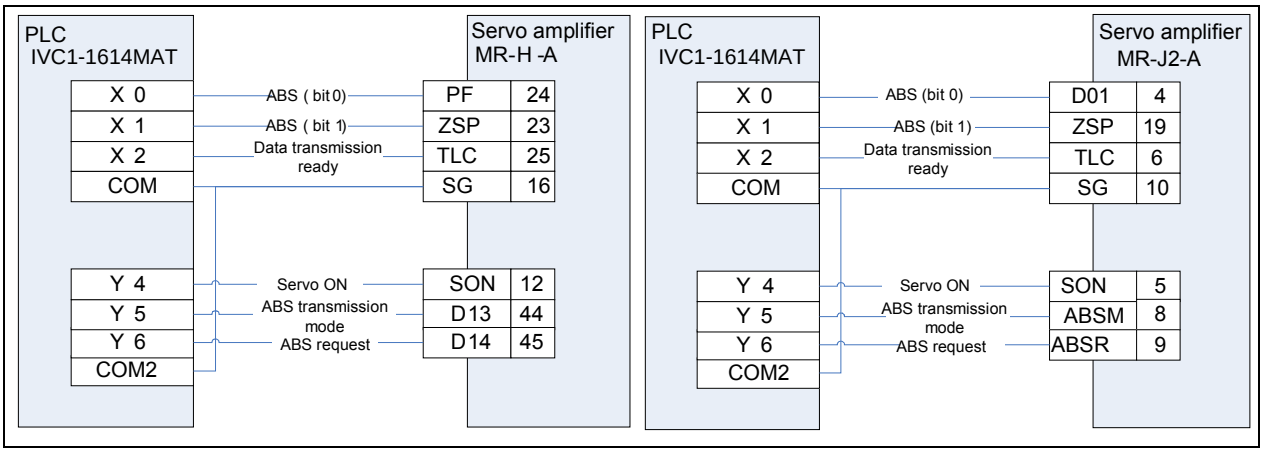
The output points occupies three consecutive Ys (***D1***, ***D1*** + 1 and ***D1*** + 2) or other bit elements

D2: the current value (32-bit) read from servo.

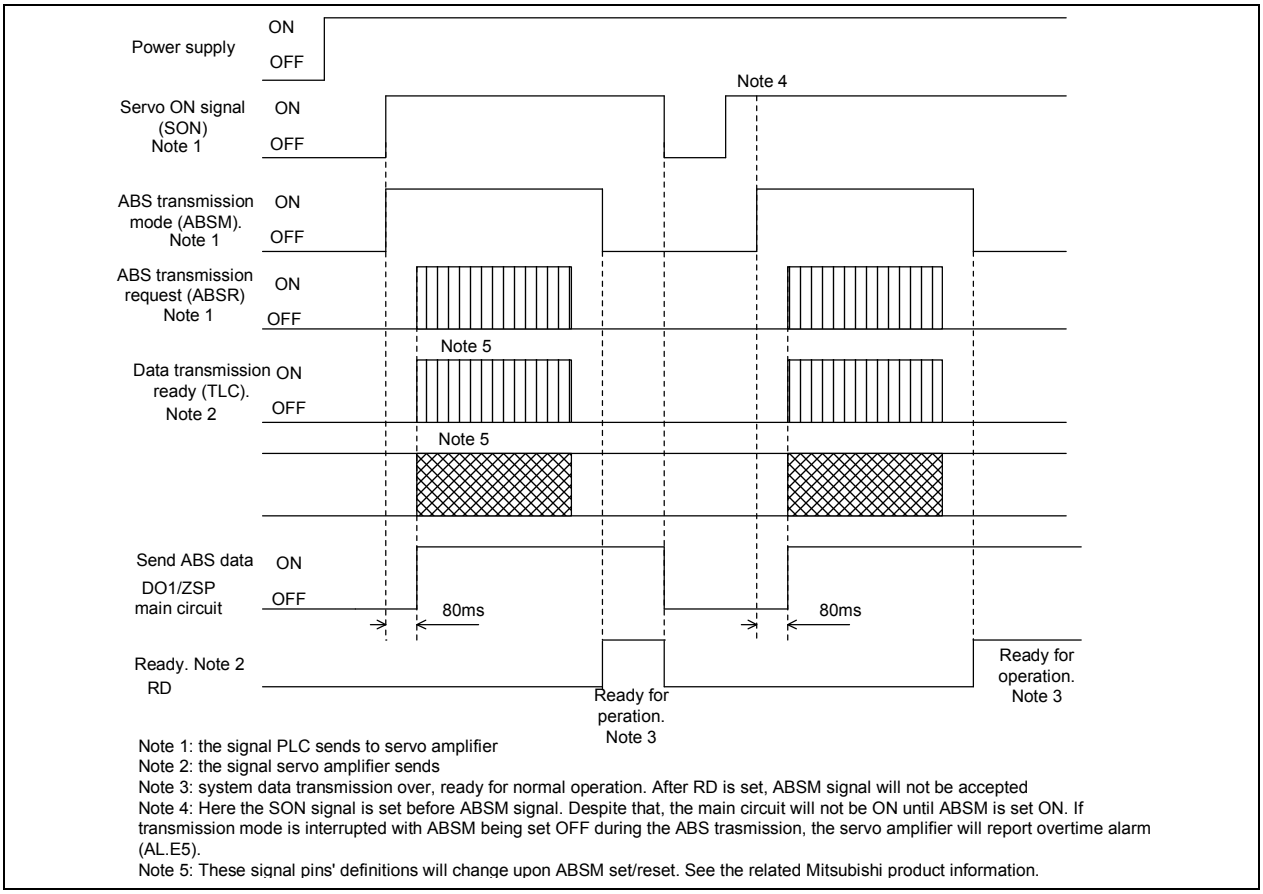
The current value occupies two word elements: ***D2*** (MSB) and ***D2*** + 1 (LSB). Because the read current value must be written into SD80 or SD82 (32-bit signed interger), you can directly specify SD80 or SD82 as ***D2***.

Function description

1. You should power on the PLC and servo amplifier at the same time, or power on the servo amplifier first, in order to make sure that the servo amplifier is ON before the PLC enters the RUN state.
2. The read current value ***D2*** can be stored in any word element, but the current value must be eventually stored in SD80 or SD82.
3. The power flow of the ABS instruction should be ON after the current value is read, otherwise the servo amplifier will turn OFF.
4. SM82 and SM83 are the output monitors of Y0 and Y1. The monitors will turn OFF after the output is complete.
5. When the power flow is valid and the servo is ON, the ABS instruction will send the transmission mode signal.
6. When the data transmission ready signal and the ABS request signal coincide with each other, the (32 + 6)bit data communication will start.
7. The data are tranmitted through the ABS 2-bit (bit0 & bit1) loop.
8. The system error code for ABS Data Read Timeout is 79; for ABS Data Read and Check Error, 80.
9. The wire connection for the I/O signals of the ABS instruction is as shown in the following figure.



Time sequence chart



Note 1: the signal PLC sends to servo amplifier
Note 2: the signal servo amplifier sends
Note 3: system data transmission over, ready for normal operation. After RD is set, ABSM signal will not be accepted
Note 4: Here the SON signal is set before ABSM signal. Despite that, the main circuit will not be ON until ABSM is set ON. If transmission mode is interrupted with ABSM being set OFF during the ABS trasmission, the servo amplifier will report overtime alarm (AL.E5).
Note 5: These signal pins' definitions will change upon ABSM set/reset. See the related Mitsubishi product information.

Note

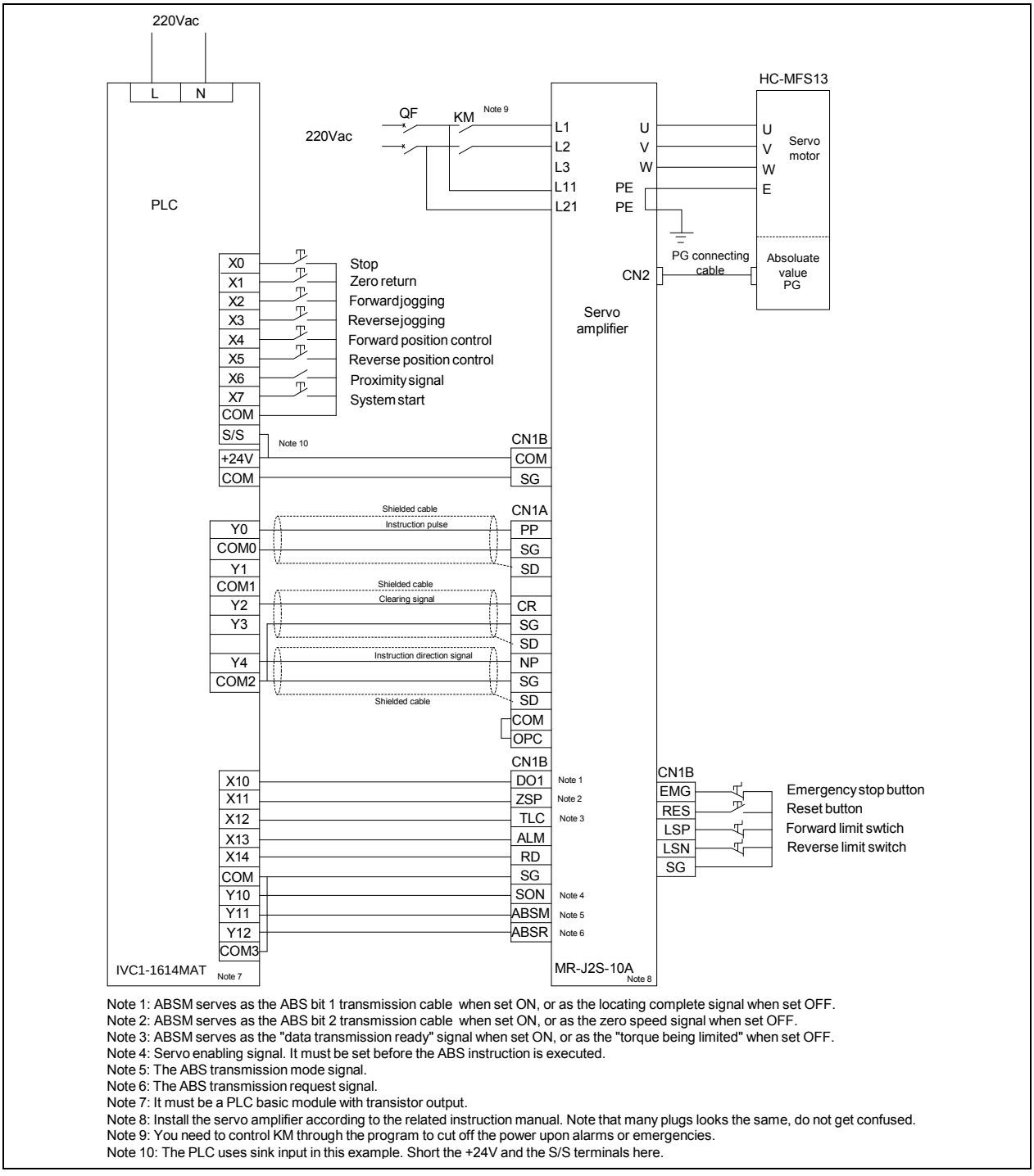
The ABS instruction supports the Mitsubishi MR ~ J2 and MR ~ J2S servo amplifiers and use its specialized data transmission protocol to read the current value of absolute position. The ABS instruction is a dedicated 32-bit instruction. For the servo amplifiers of other brands, reading the current value of absolute position requires communication or other designated methods. When the ABS instruction is executed, the related I/O points will be processed accordingly. Therefore, the ABS instruction is applicable only to Mitsubishi servo amplifiers.

6.17.12 Application Examples

Mechanical diagram

Refer to Figure 6-2, and see the following example of an absolute coordinate system based on a single screw rod.

System wiring diagram（0418）



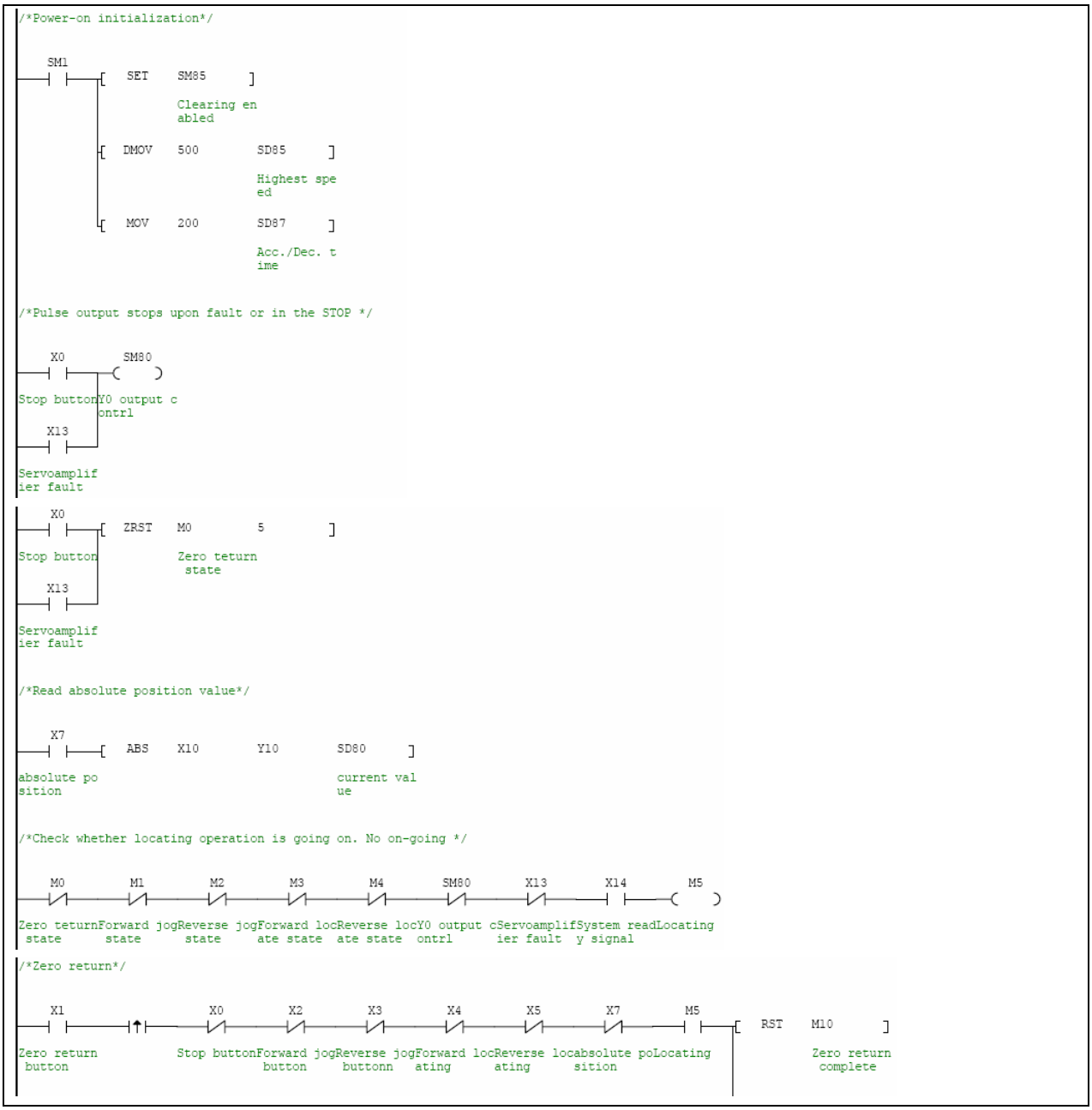
Note 1: ABSM serves as the ABS bit 1 transmission cable when set ON, or as the locating complete signal when set OFF.
Note 2: ABSM serves as the ABS bit 2 transmission cable when set ON, or as the zero speed signal when set OFF.
Note 3: ABSM serves as the "data transmission ready" signal when set ON, or as the "torque being limited" when set OFF.
Note 4: Servo enabling signal. It must be set before the ABS instruction is executed.
Note 5: The ABS transmission mode signal.
Note 6: The ABS transmission request signal.
Note 7: It must be a PLC basic module with transistor output.
Note 8: Install the servo amplifier according to the related instruction manual. Note that many plugs looks the same, do not get confused.
Note 9: You need to control KM through the program to cut off the power upon alarms or emergencies.
Note 10: The PLC uses sink input in this example. Short the +24V and the S/S terminals here.

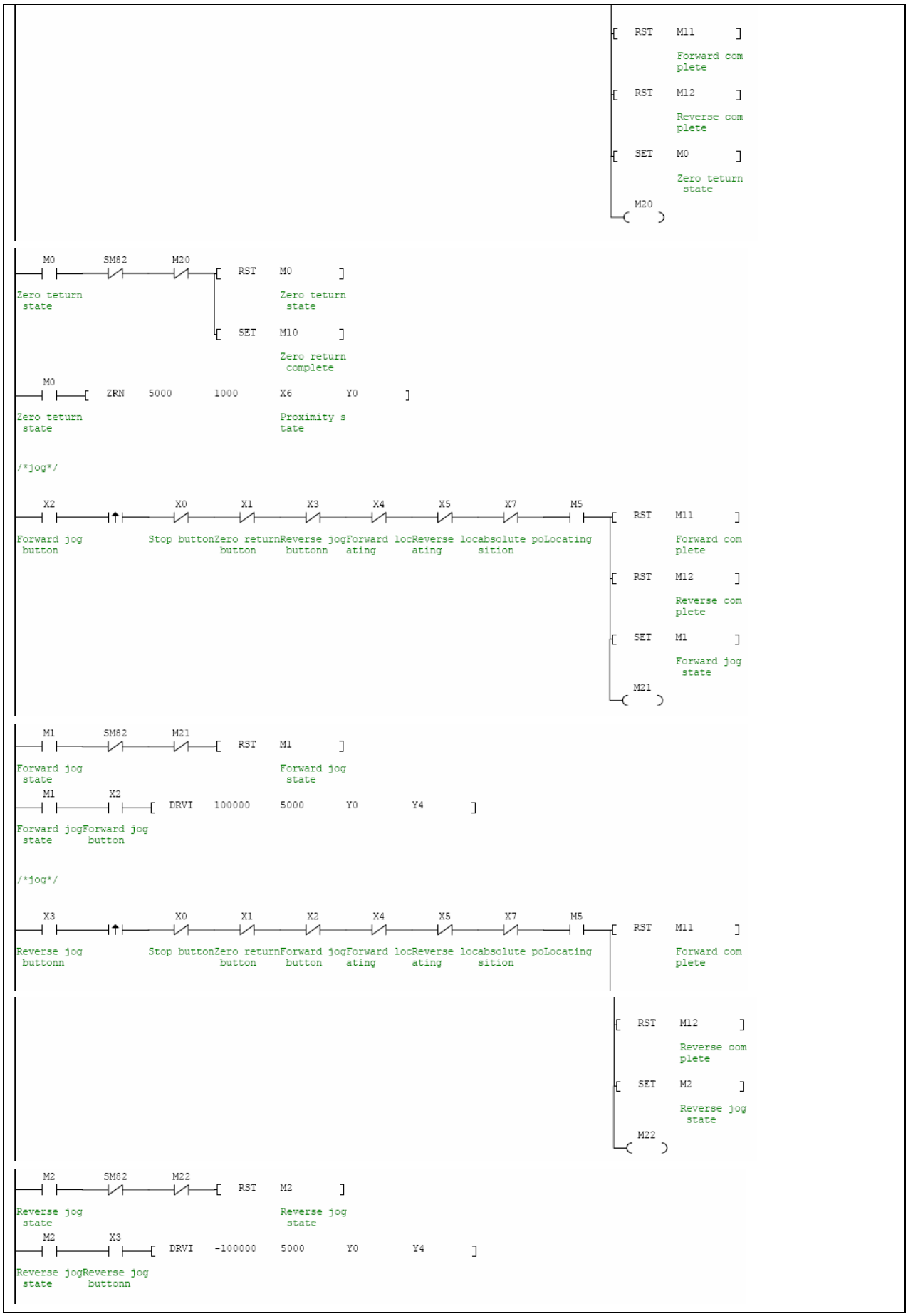
Figure 6-3 System wiring diagram

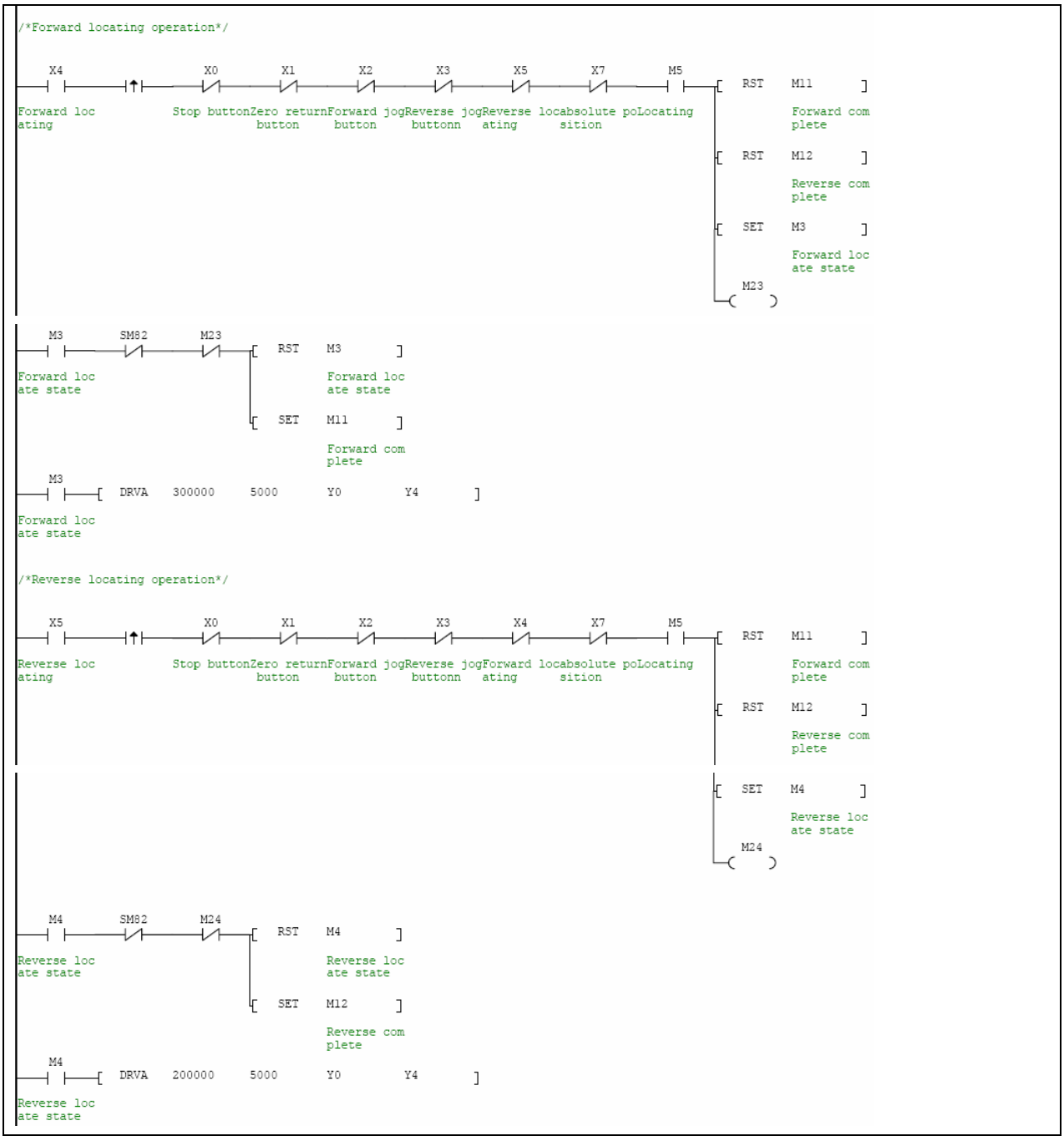
Program example

The aimed functions of the program are:

- When the PLC enters the RUN state, read the absolute position data from the servo amplifier through the ABS instruction or through communication (note that in this case, the servo amplifier must be powered on with the PLC at least at the same time)
- SM85 is set after PLC enters the RUN state to set the output clearing function, and Y2 will output a clearing pulse whenever zero return occurs.
- Press the JOG+ button to jog forward.
- Press the JOG - button to jog backward.
- When the workbench is away from the zero point farther than the proximity detection point, press the Zero Return button to make it return to the zero point.
- Press the STOP button and a running workbench will stop immediately.
- Use the Forward/Reverse Positioning control buttons to locate the workbench




RST M11
Forward com plete
RST M12
Reverse com plete
SET M0
Zero teturn state
M20
M0 SM82 M20
RST M0
Zero teturn state
Zero teturn state
SET M10
Zero return complete
M0
ZRN 5000 1000 X6 Y0
Zero teturn state
Proximity s tate
/*jog*/
X2 X0 X1 X3 X4 X5 X7 M5
Forward jog button
Stop button
Zero return button
Reverse jog buttonn
Forward locating
Reverse locating
absolute position
Locating
RST M11
Forward com plete
RST M12
Reverse com plete
SET M1
Forward jog state
M21
M1 SM82 M21
RST M1
Forward jog state
Forward jog state
M1 X2
DRVI 100000 5000 Y0 Y4
Forward jog state
Forward jog button
/*jog*/
X3 X0 X1 X2 X4 X5 X7 M5
Reverse jog buttonn
Stop button
Zero return button
Forward jog button
Forward locating
Reverse locating
absolute position
Locating
RST M11
Forward com plete
RST M12
Reverse com plete
SET M2
Reverse jog state
M22
M2 SM82 M22
RST M2
Reverse jog state
Reverse jog state
M2 X3
DRVI -100000 5000 Y0 Y4
Reverse jog state
Reverse jog buttonn


/*Forward locating operation*/
X4
X0
X1
X2
X3
X5
X7
M5
RST M11
Forward locating
Stop button
Zero return button
Forward jog button
Reverse jog buttonn
Reverse locating
absolute position
Locating
Forward complete
RST M12
Reverse complete
SET M3
Forward locate state
M23
M3
SM82
M23
RST M3
Forward locate state
SET M11
Forward complete
M3
DRVA 300000 5000 Y0 Y4
Forward locate state
/*Reverse locating operation*/
X5
X0
X1
X2
X3
X4
X7
M5
RST M11
Reverse locating
Stop button
Zero return button
Forward jog button
Reverse jog buttonn
Forward locating
absolute position
Locating
Forward complete
RST M12
Reverse complete
SET M4
Reverse locate state
M24
M4
SM82
M24
RST M4
Reverse locate state
SET M12
Reverse complete
M4
DRVA 200000 5000 Y0 Y4
Reverse locate state

Chapter 7 SFC Tutor

This chapter introduces the basic concepts and programming methods of Sequential Function Chart (SFC). In addition, the points to note during the programming is also introduced.

7.1 Introduction To SFC 206
7.1.1 What Is SFC....206
7.1.2 What Is SFC Of IVC Series PLC....206
7.1.3 Basic Concepts Of SFC 206
7.1.4 Programming Symbols And Their Usage 206
7.1.5 SFC Program Structure....207
7.1.6 Execution Of SFC Program....211
7.2 Relationship Between SFC Program And LAD Program 211
7.2.1 STL Instruction And Steps 211
7.2.2 SET Instruction 212
7.2.3 RET Instruction And SFC Program Section 212
7.2.4 OUT Instruction And RST Instruction....212
7.2.5 SFC Selection Branch, Parallel Branch And Merge 212
7.3 How To Program With SFC....212
7.4 Points To Note In SFC Programming 213
7.4.1 Common Programming Errors 213
7.4.2 Programming Tricks....215
7.5 Examples Of SFC Programming 217
7.5.1 Simple Sequential Structure....217
7.5.2 Selection Branch Structure 219
7.5.3 Parallel Branch Structure 222

7.1 Introduction To SFC

7.1.1 What Is SFC

The Sequential Function Chart, or SFC, is a programming language developed and got popular in recent years. SFC can turn a PLC program into a structured flow chart. By using standard programming symbols and grammar compliant with IEC61131-3, the SFC can divide a complicated operation process into sequential procedures that are linked together with conditioned transfers, so as to realize sequence control.

The SFC edited programs are direct and sequential. Each procedure and transfer condition are relatively simple program sections, ideal for the sequential control application. These advantages explain why it is finding wider application.

7.1.2 What Is SFC Of IVC Series PLC

The SFC of IVC series PLC is a programming language used by Invt IVC series PLCs. Besides standard SFC functions, the SFC of IVC series PLC can provide multiple nested LAD program blocks.

The program edited with SFC of IVC series PLC can be converted into LAD or IL program.

The SFC of IVC series PLC can also support up to 20 independent procedures. The independent procedures can run independently, that is to say, the steps within different independent procedures are scanned and executed separately. However, jumping among independent procedures is enabled.

7.1.3 Basic Concepts Of SFC

The SFC has the following two basic concepts: step and transfer. Other concepts, like jump, branch and multiple independent procedures, all evolve from the two basic concepts.

Steps

1. Definition

A step is actually a program section, representing a work state or move in the sequence control process. Putting multiple steps together in a organic way can form a complete SFC program.

2. Execution of steps

In a SFC program, each step is represented by a fixed S element.

A step is valid when it is being executed. For a valid step, its corresponding S element is ON, and the PLC will scan and execute its instructions. While a step not being executed is invalid. For a invalid step, its corresponding S element is OFF, and the PLC will not scan and execute its instructions.

Transfer

The sequence control process is actually a series of step transfers. A PLC executing a certain step will, if certain logic conditions are met, leave the current step to enter and execute a new step. That transition is called the step transfer.

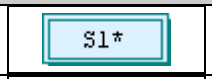
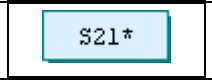
The logic condition that triggers the transfer is called the transfer condition.

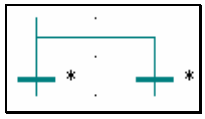
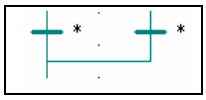
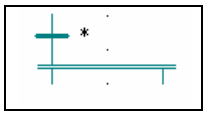
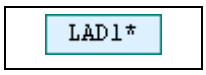
7.1.4 Programming Symbols And Their Usage

Programming Symbol

The IVC series PLC SFC programming language consists of the following programming symbols:

Table 7-1 Programming symbols

Symbol name	Symbol	Description
Initial step		A initial step of SFC, numbered as Sn. The “n” must not repeat. The execution of a SFC program must start with an initial step, whose S element range is S0 ~ S19
Normal step		A normal step, numbered as Sn. The “n” must not repeat. The S element range for the normal step is S20--S991
Transfer		A transfer. It can be built-in with a transfer condition (a embeded LAD). You can compile the transfer condition so that the S element connected with this transfer will be set when the condition is met and enter the next step. The transfer must be used between steps.

Symbol name	Symbol	Description
Jump		A jump, used after the transfer. It can set the specified S element to ON when the transfer conditions are met. It is used to cycle or jump among steps
Reset		A reset, used after the transfer. It can set the specified S element to OFF when the transfer conditions are met. It is used to end the SFC program
Selection branch		Multiple independent transfer conditions, used after a step. When the transfer condition of one branch is met, the last step will end and the next step of the corresponding branch will start. After that, no other parallel branch will be selected
Selection merge		A merge of selection branches. When the transfer condition of one branch is met, the last step will end and the next step will start
Parallel branch		Connected after a step, the parallel branches share the same transfer conditions. When the transfer conditions are met, the parallel branches are validated and executed at the same time
Parallel merge		A merge of parallel branches. The next step will start only after all the parallel steps are finished and the transfer conditions are met
Ladder chart block		The LAD block presents LAD instructions for operations besides the SFC flow, such as starting the initial step and other general operations

Usage Of Programming Symbols

1. The initial step can be used alone. If you connect it with other symbols, you must use it at the start of you SFC program, and use a transfer condition symbol after it.
2. However, you cannot connet the LAD step with other symbols.
3. You must connect an normal stepwith transfer condition symbols, for the ordinary steps cannot be used alone.
4. The reset and jump should both be preceded by a transfer and followed by nothing.
5. Neither the transfer nor the jump can exist alone in a program.

7.1.5 SFC Program Structure

The structure of a SFC program is classified into three types: simple sequential structure, selection branch structure and parallel structure. Besides, the jump structure is also a special form of the selection branch structure.

Simple sequential structure

Figure 7-1 shows a simple structured SFC program and its LAD counterpart.

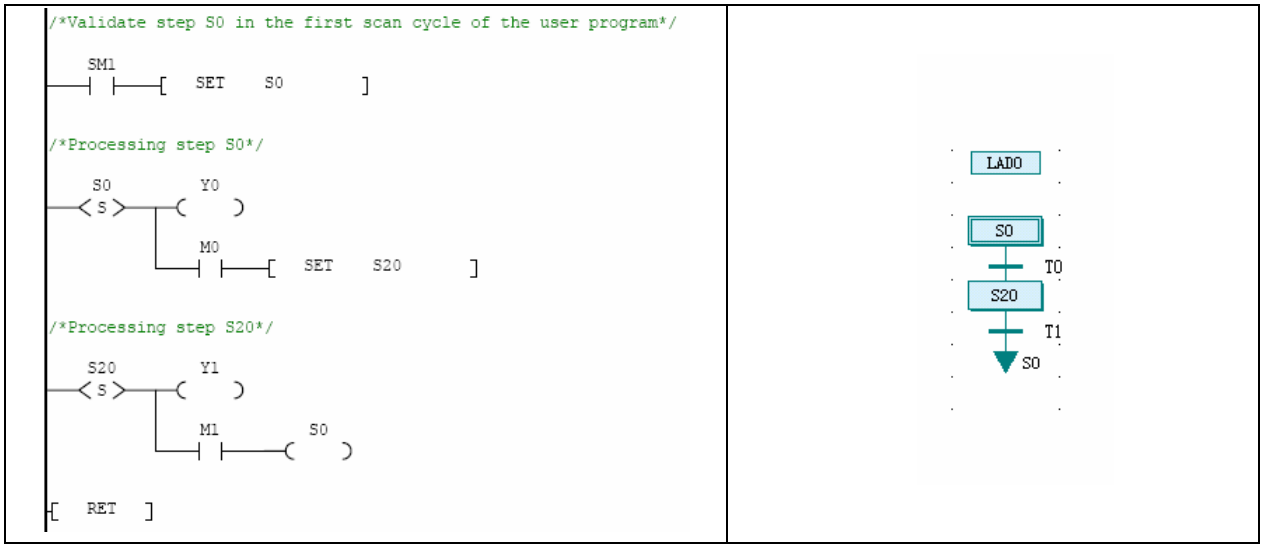


Figure 7-1 A simple structured SFC program and its LAD counterpart

In a simple structured SFC program, when the step transfer conditions are met, the program will run from the current step to the next step in a linear flow. At the last step, when the transfer conditions are met, the SFC program section will either end or transfer to the initial step.

1. Ladder chart block

The ladder chart block is used to start SFC program section. To be specific, to set the S element of the initial step to ON. In the preceding figure, the program uses the power-on startup mode.

The ladder chart block can also be used as other general program sections besides the SFC program.

2. Initial step

As shown in Figure 7-1, the initial step is started by a ladder chart block. The range of S elements for initial-step is 0 ~ 19.

3. Normal step

The normal step is the main component of the program. The range of S elements for normal-step is 20 ~ 991 (for IVC2) or 20 ~ 1023 (for IVC1).

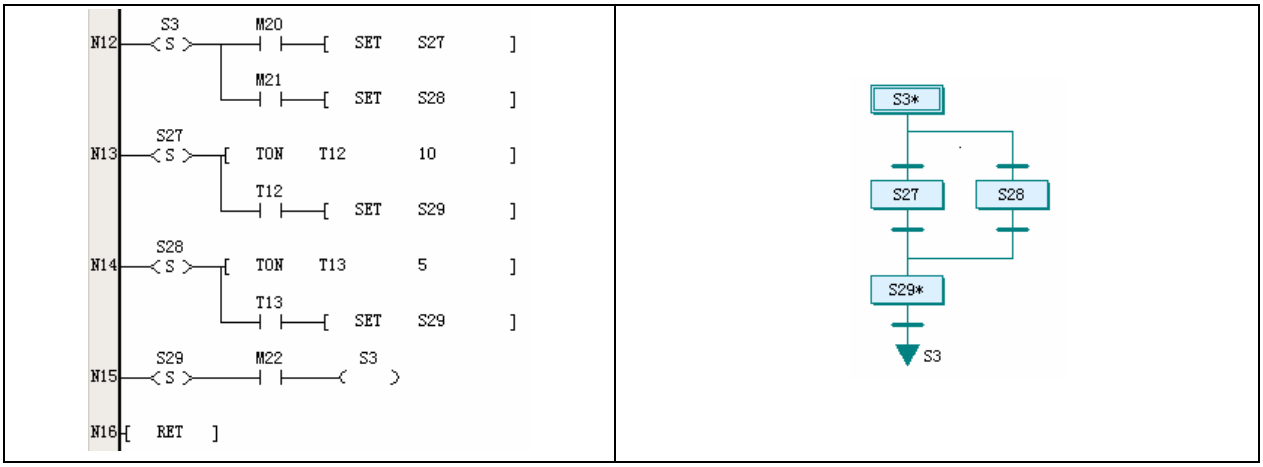
4. Transfer or reset

The program shown in Figure 7-1 is ended with a jump, which leads the program to the initial step. This is a cyclic program.

However, the program can also be ended with a reset, which can reset the status of the last step, end a program, and wait for the next round of execution.

Selection branch structure

The selection branch structure is shown in the following figure, with LAD on the left and SFC on the right.



1. Selection branch

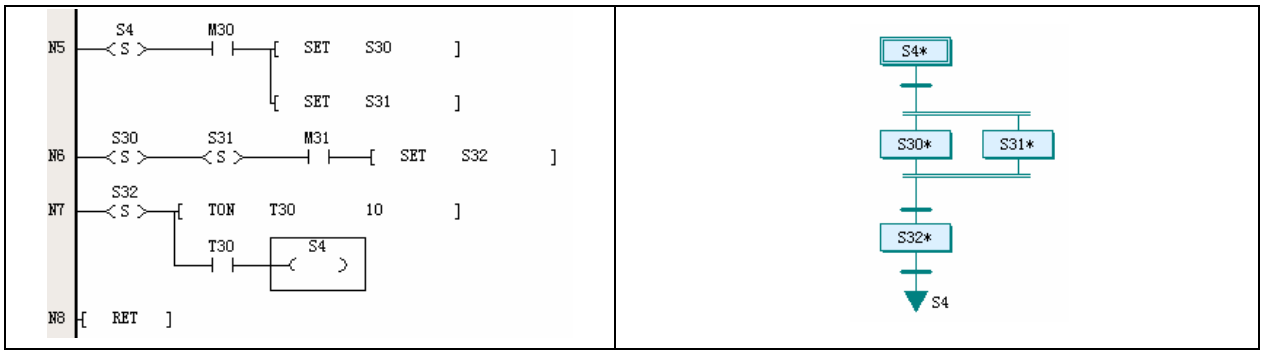
A branch step is validated when its corresponding transfer conditions are met. You must ensure that the transfer conditions of different branches are all exclusive, so as to make sure that each time only one branch will be selected. As shown in the preceding figure, steps S27 and S28 in row N12 of LAD program are transferred from conditions M20 and M21 respectively. The conditions M20 and M21 must not be met at the same time in order to ensure that S27 and S28 will not be selected at the same time.

2. Selection merge

The selection merge is the structure where all selection branches merge to the same step. The transfer conditions are set respectively. As shown in the preceding figure, the transfer condition in the branch of S27 is that time is up for T12, while that for the branch of S28 is that time is up for T13. However, the results are the same: step S29 starts.

Parallel branch structure

The parallel branch structure is shown in the following figure, with LAD on the left and SFC on the right.



1. Parallel branch

When the transfer conditions are met for the parallel branches, all branch steps will be validated at the same time. This enables the PLC to process multiple procedures at the same time, a quite usual sequential control process. As shown in the preceding figure, in program row N5, the steps S30 and S31 will be validated at the same time when condition M30 is met.

2. Parallel merge

The parallel merge is the structure where all parallel branches merge to the same step by invalidating all branch steps at the same time. As shown in the preceding figure, in program row N6, when the program is running both S30 and S31 at the same time, if condition M31 is met, the program will start S32 and end S30 & S31.

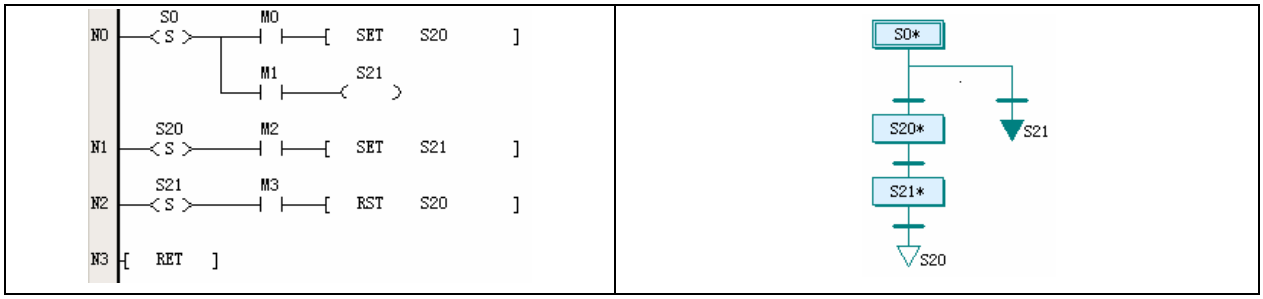
The sequential control behind the parallel merge structure is that no next step can be executed unless all the parallel steps are finished.

Jump structure

The applications of jumps include: to omit certain steps, to recycle by returning to the initial step or a normal step, and to jump to another independent procedure.

1. Omitting certain steps

In a procedure, when certain steps are unnecessary under certain conditions, the program can jump directly to the needed step and omit the unnecessary steps, as shown in the following figure, with LAD on and left and SFC on the right.



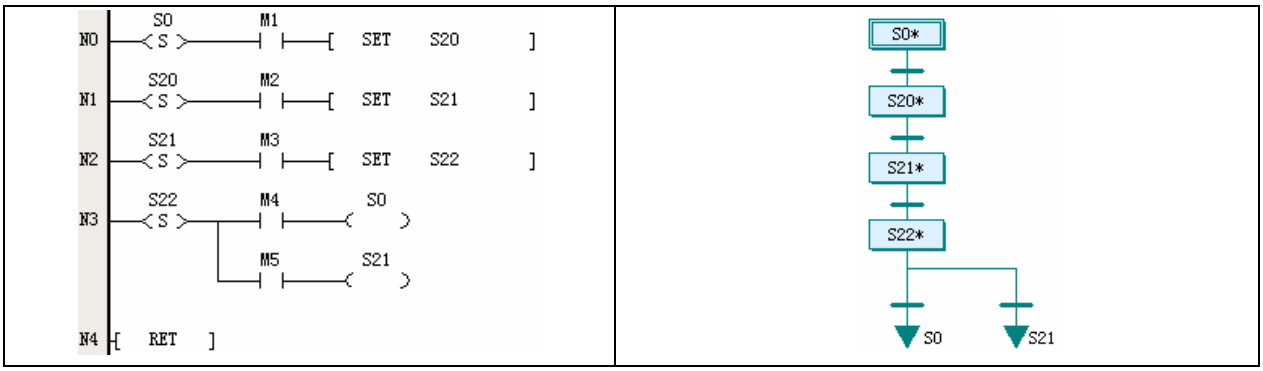
In the SFC program shown in the preceding figure, S21 is used as the jump, while step S20 is omitted. The jump is actually a selection branch.

While in the LAD counterpart, the second branch in row N0 is the jump instruction, which uses the OUT coil instead of the SET instruction in the transfer. When step S0 is valid, and if M1 is ON, the program will jump to step S21.

2. Recycling

In a procedure, when it is necessary to recycle a part or all of the steps under certain conditions, you can use the jump function. you can recycle a part of the steps if you jump to a previous normal step, or all the step if you jump to the initial step.

Shown in the following figure is a program that can realize the above two recycles, with LAD on the left and SFC on the right.



In the SFC, when step S22 is valid, the program may jump to step S21 to recycle S21 and S22, or jump to the initial step S0 to recycle all the steps. Which recycle will be selected is determined by a selection branch structure.

While in the LAD, the two kinds of jumps are realized in row N3, where you can see the OUT coil.

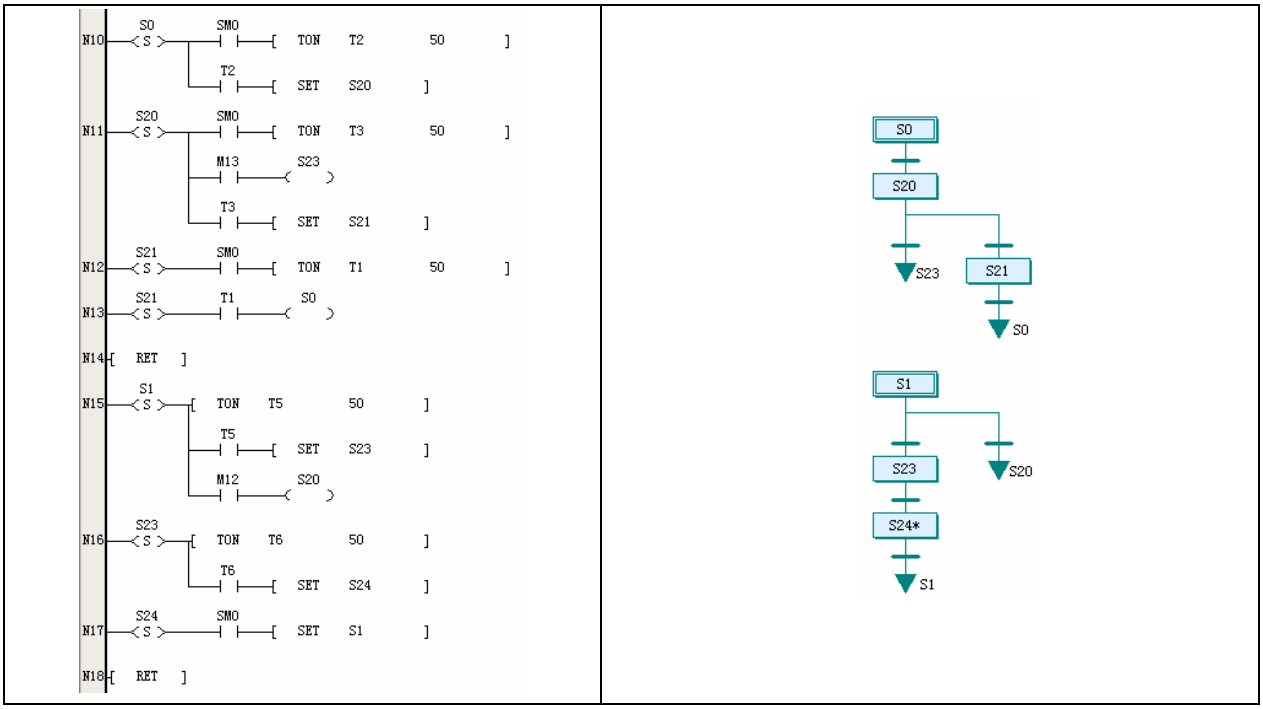
3. Jumping to another independent procedure

The SFC of IVC series PLC supports multiple independent procedures and jumping among these procedures is allowed. You can set certain transfer conditions in an independent procedure for jumping to a random step (initial or normal) of another independent procedure.

Note

Jumping among multiple independent procedures complicates the program. Use it with prudence.

Shown in the following figure is a jump from one independent procedure to another, with LAD on the left and SFC on the right.



In the SFC, when the S0 in the first procedure is valid, the program can jump to step S23 in the second procedure under certain conditions; while in the second procedure, the program can also jump to step S20 in the first procedure under certain conditions.

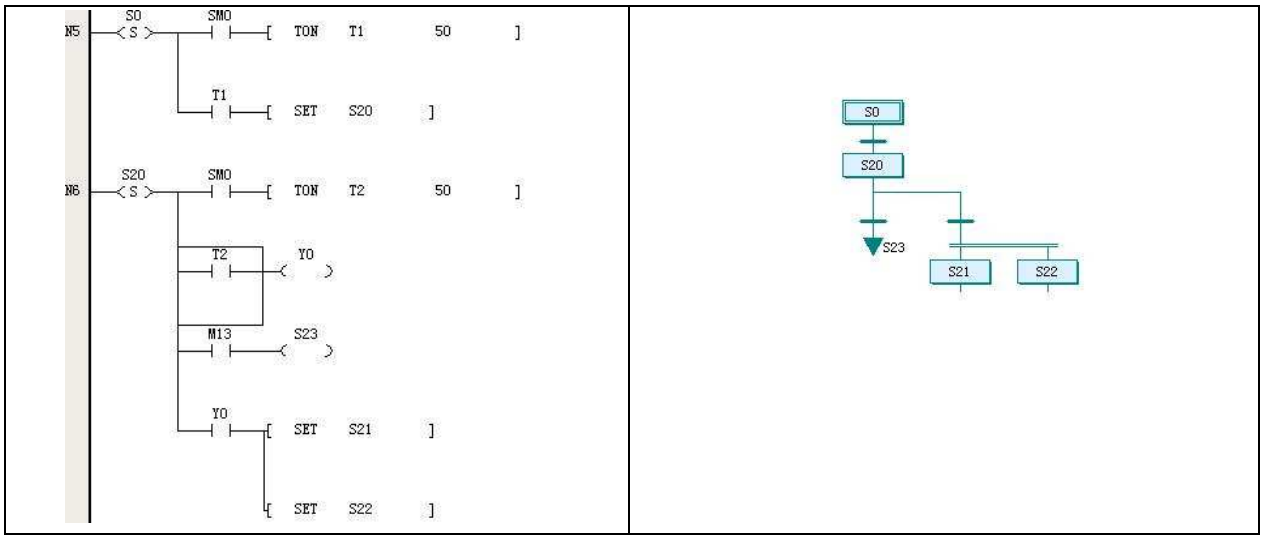
As shown in the preceding figure, the jump is based on a selection branch structure. When the program jumps to another procedure, all the steps in the original procedure will become invalid. As the example shows, if the program jumps to step S23 in the second procedure from step S20 in the first procedure, step S20 and all the other steps in the first procedure will become invalid.

7.1.6 Execution Of SFC Program

The similarity between the execution of a SFC program and that of a LAD program is that they both carry out cyclic scanning from up to down and from left to right.

On the other hand, their difference lies in that in a SFC program, the steps' validity will change according to certain conditions, and only valid steps can be executed. While in a LAD main program, the whole program will be scanned and executed in each scan cycle.

As shown in the following figure, the program on the right is the LAD counterpart of the SFC program on the left. When step S20 is valid, the T2 timer will be scanned and start timing. Steps S21 and S22 will not be executed before T2 counter reaches the preset value, and S23 will not be executed when M13 is OFF.



The S elements state will switch between ON and OFF according to the transfer conditions, thus making the program transfer from one step to another. When a S element changes from ON to OFF, the output elements of the corresponding step will be cleared or reset. For details, see *5.3.1 STL: SFC State Load Instruction.*

Note

1 . The SFC program of IVC series PLC usually contains LAD program blocks that are used to handle operations besides the flow, including starting the SFC. The LAD program blocks are not controlled by the S elements and will be executed in every scan cycle.

2 . Because the state change of the S element will affect the embedded instructions of the corresponding step, and the switch-over between two steps takes some time, it is necessary to observe certain rules during the SFC programming. For details, see *7.4 Points To Note In SFC Programming*.

7.2 Relationship Between SFC Program And LAD Program

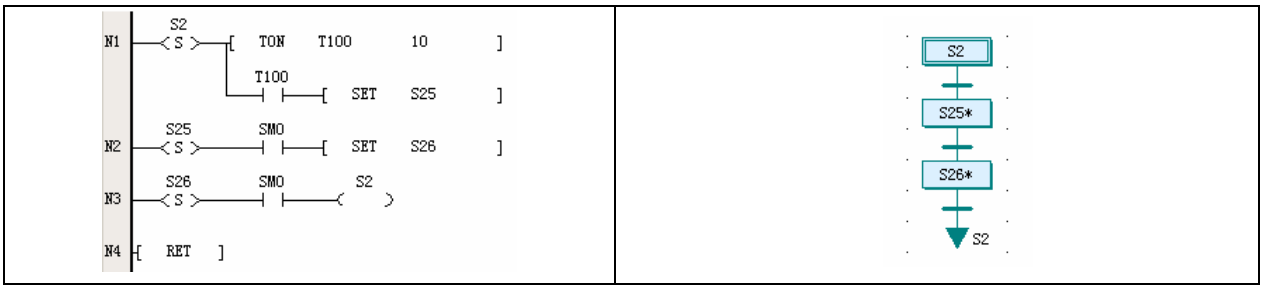
A SFC program can take the form of a LAD program, which can help understanding the SFC program structure.

In the LAD program, the SFC symbols are replaced with various SFC instructions, while the procedures are represented by various structures.

7.2.1 STL Instruction And Steps

All SFC steps are represented by S elements. In a LAD program, a step is started by a STL instruction.

Shown in the following left figure is the LAD program of a simple sequential structure, and the right figure is its corresponding SFC program.



As shown in the LAD program, the S2 step starts with a STL instruction, and the following TON instruction is the internal instruction of S2. A step can be made up of multiple instructions. A SFC step is actually a relatively complete program section, almost consistent with the LAD counterpart.

The difference between a initial step and an normal stepis that they use different S elements.

For detailed information about the STL instruction, see *5.3.1 STL: SFC State Load Instruction*. Note that when the step changes from ON to OFF, the destination operands of its internal instructions will be cleared. Such instructions include OUT, TON, TOF, PWM, HCNT, PLSY, PLSR, DHSCS, SPD, DHSCI, DHSCR, DHSZ, DHST, DHSP and BOUT.

Note

Because the PLC runs in continuous scan cycles, after a step transition, the instructions of the original step will not be affected by the change of ON to OFF until the next scan cycle. See *7.4.1 Common Programming Errors*.

7.2.2 SET Instruction

As shown in the preceding figure, the transfer symbols in the SFC program on the right are realized through the SET instructions in the LAD program on the left.

The transfer conditions consist of the NO contacts before the SET instruction. The NO contacts are controlled by internal instructions or through external operation.

When the power flow of the SET instruction is valid, the specified step becomes valid, and the current valid step is invalidated. A step transfer is thus complete.

7.2.3 RET Instruction And SFC Program Section

As shown in the preceding figure, the SFC program on the right starts with a S2 initial step symbol, and returns to S2 after two ordinary steps. While in the LAD program, the SFC program section must end with the RET instruction.

The RET instruction can be only used in a main program.

7.2.4 OUT Instruction And RST Instruction

As shown in the preceding figure, the jump to S2 is realized in LAD program by the N3 row, which uses an OUT instruction. The destination operand of the OUT instruction (jump) can be in any independent procedure.

If the reset S26 is used, line N3 in the LAD program will be a RST instruction, which can reset the last step S26.

7.2.5 SFC Selection Branch, Parallel Branch And Merge

See *Selection branch structure* in *7.1.5 SFC Program Structure* for the LAD counterpart of SFC selection branches.

See *Parallel branch structure* in *7.1.5 SFC Program Structure* for the LAD counterpart of SFC parallel branches.

7.3 How To Program With SFC

1. Analyse the work flow and determine the program structure

The structure of a SFC program is classified into three types: simple sequential structure, selection branch structure and parallel branch structure. Besides, the jump structure is also a special form of the selection branch structure.

To program with SFC, the first thing to do is to determine the structure of the flow. For example, a single object passing through a sequential flow is a simple sequential structure. Multiple objects with different parameters to be processed asynchronously needs a selection branch structure. While a cooperation of multiple independent mechanical elements may need a parallel branch structure.

2. Determine the major procedures and transfer conditions to draw a draft flow chart

After determining the strucuture, you need to figure out the major procedures and transfer conditions. By deviding the work flow into smaller operation stages, you can get the procedures. End each procedure with a transfer condition, and you can get the draft of the work flow.

3. Make a SFC program according to the draft flow chart

Use the SFC programming language in AutoStation to make a SFC program out of the draft flow chart. By now you have got an executable PLC program, but you still need to refine it.

4. Make a list of input and output points, and determine the objects of each procedure and the transfer conditions

Generally, the input points are transfer conditions, while the output points are the operation objects. In addition, with the list, you can further modify the SFC.

5. Input the steps and transfer conditions

In the SFC program you just made, right click a SFC symbol and select **Embedded Ladder Chart** in the shortcut menu. You are then able to edit the step or transfer condition through the LAD programming language.

6. Add functional program sections to the program

Do remember to add program sections that provide general functions, such as start, stop and alarm functions. Such program sections should all be put in LAD blocks.

Note

The start and stop operations are crucial for personal and equipment safety. Considering the special features of SFC program, make sure that all outputs that should be stopped are shut down when the PLC is stopped.

7.4 Points To Note In SFC Programming

The STL instruction has some special characteristics, and the PLC scans instructions cyclically by their display order. Because of these reasons, there are some points to note during SFC programming.

7.4.1 Common Programming Errors

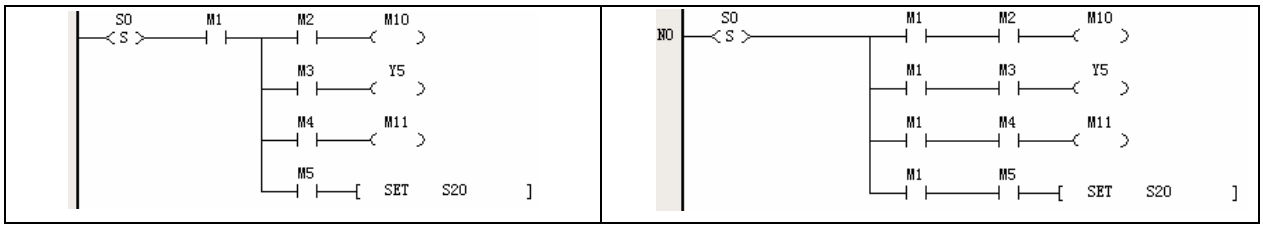
1. Reusing steps

In the same PLC program, each step corresponds to a unique S element and cannot be reused.

Note this when editing a SFC program using the LAD editor.

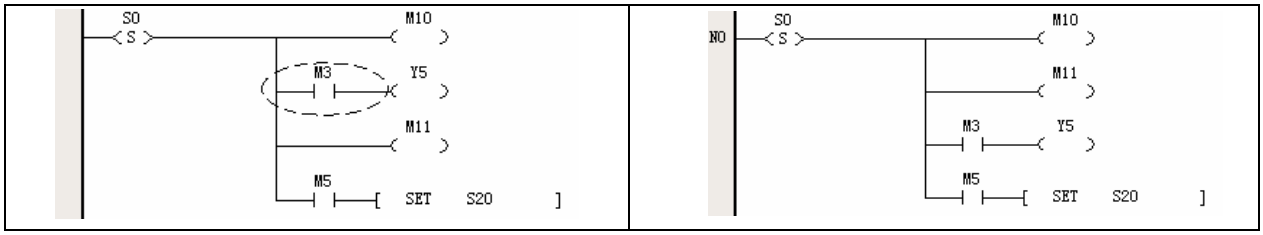
2. Setting branches after a transfer condition

Setting conditioned branches after a transfer condition is prohibited in SFC programming, as shown in the left figure below. Instead, you should change it into the right figure below.



3. Connecting output coils to internal bus after a NC or NO contact instruction

Connecting output coils to the internal bus after a NO or NC contact instruction in a branch is prohibited, as shown in the left figure below. In stead, you should change it into the right figure below.

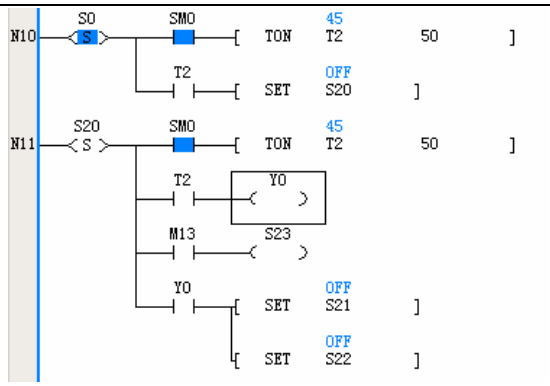


4. Reusing the same element in neighboring steps

The PLC scans instructions by their display order. The scanning of the current step and that of the next step are closely joined together.

Therefore, after a STL instruction is executed, although certain elements of the instruction will be reset (see *5.3.1 STL: SFC State Load Instruction*), the reset will not be carried out until the next scan cycle. That means, at the moment of the transfer, the elements of the last step retains their states and values until the step is scanned in the next cycle.

As shown in the following figure, the two neighboring steps use the same timer: T2. When the S0-S20 transfer occurs, the T2 will retain its value and state, rendering the step S20 unable to perform as it is designed. The program will jump directly to S21 and S22. Therefore, it should be noted that, although reusing elements in a program is not prohibited, you should avoid reusing them in neighboring steps, or accidents may occur.

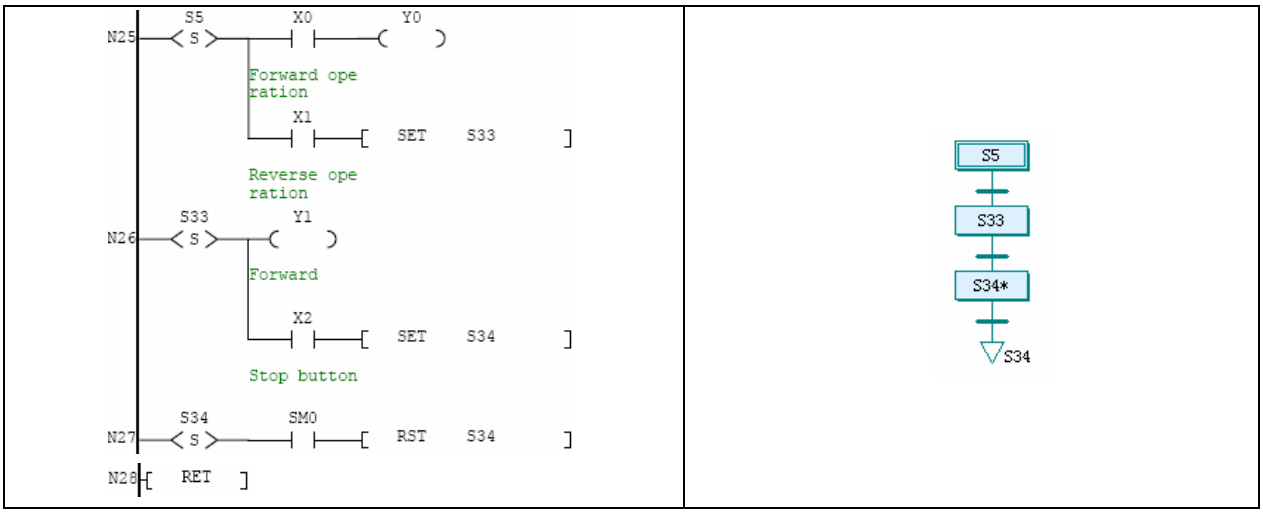


5. Failing to inter-lock elements

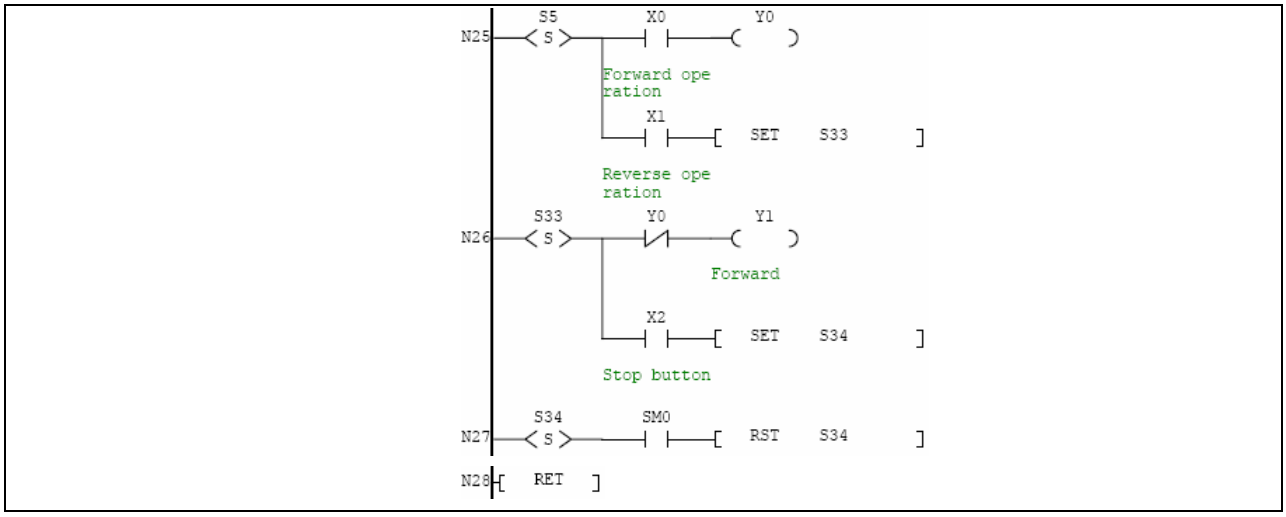
During SFC programming, certain elements may become contradictary to each other under some special transfer conditions. Inter-locking is then necessary.

Take the following forward & backward operation program as an example, where Y0 and Y1 are respectively forward and backward output. X0 is forward operation, X1 is backward operation, and X2 the is stop button. Y0 and Y1 should be inter-locked, that is to say, they should not be ON at the same time.

However, in this example, when Y0 is ON, if X1 is ON and the S33 is validated, Y1 will be also ON, within the same scan cycle with Y0.



Therefore, you need to add an interlock to the program by adding a Y0 NC contact before the Y1 output coil, as shown in the following figure.

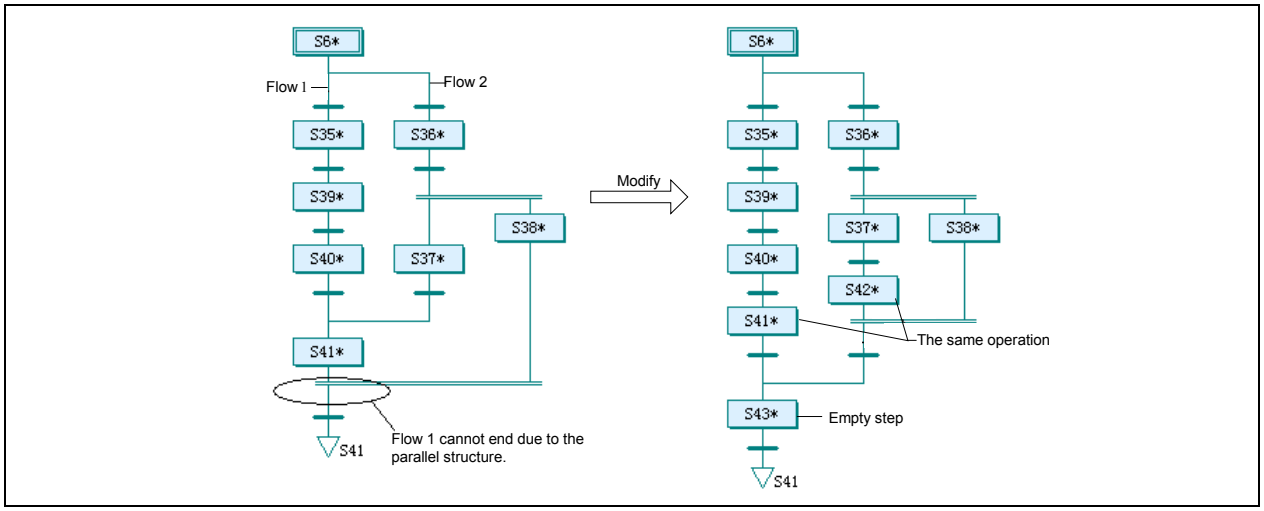


6. Confusing jumps with transfers

Jumps are used between different procedures or non-neighboring steps, while transfers are used between neighboring steps. It is prohibited to change an output coil into a SET instruction where a jump should be used, or change a output coil into a SET instruction where a transfer should be used.

7. Using parllel merge for selection branches

In a selection branch structure, only one selection is valid. However, when it is mixed with a parallel branch structure, the selection branch structure may never end. As shown in the following figure. In the left part, when flow 1 runs to step S41, it meets the transfer condition of a parallel merge. But the system will never run flow 2. Therefore the transfer will never occur, making flow 1 unable to end.



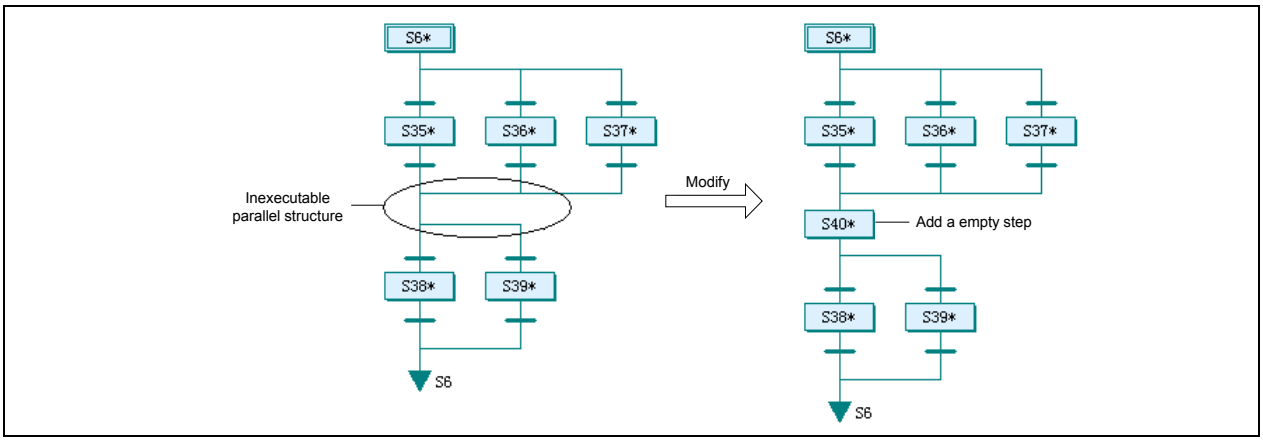
As shown in the right part, to correct it, you need to add a step S42 whose function is the same as S41. Then add an empty step S43 that serves as a structural block without actual function. Design the transfer conditions for S38, S41 and S43 according to the actual situation.

7.4.2 Programming Tricks

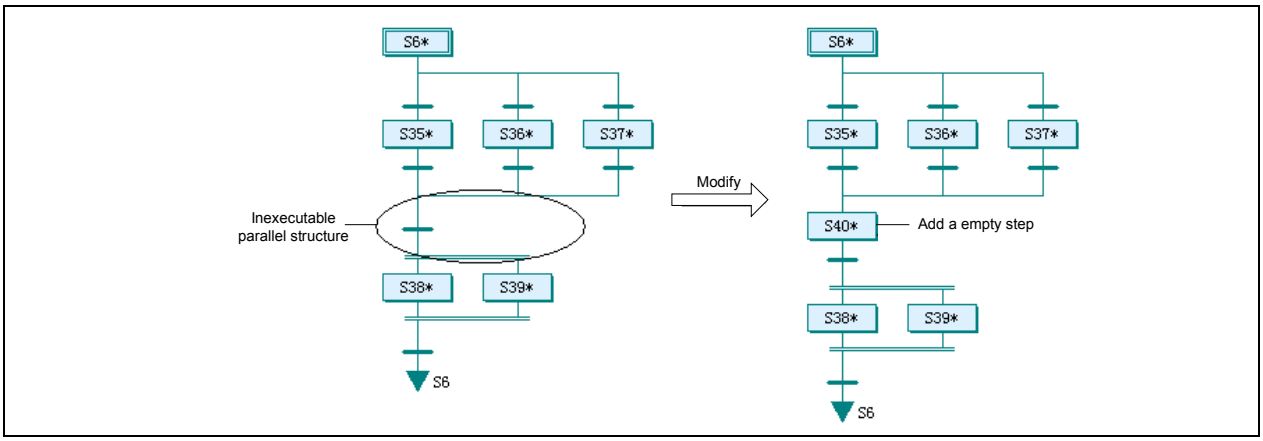
1. Making use of empty steps

You may need empty steps to deal with the branches with grammatical problems. The empty steps do not provide actual operation, but a necessary node in structure before the next transfer. See the following example.

In the left figure below, the selection merge is connected immediately with another selection branch structure. That is prohibited. You can change it as the right figure shows: add an empty step.



In the left figure below, the selection merge is connected immediately with a parallel branch structure. That is prohibited too. You can also change it as the right figure shows: add an empty step.

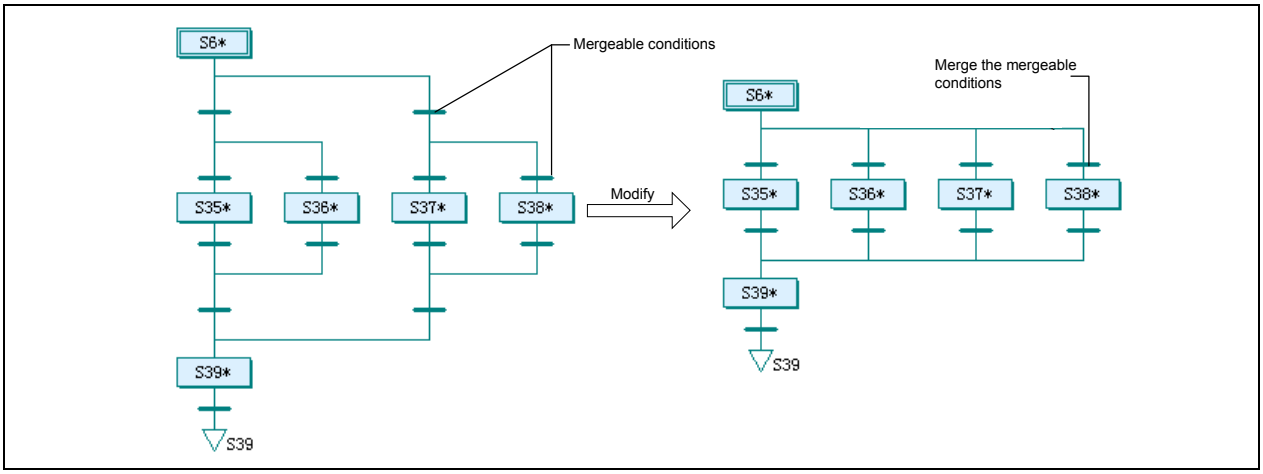


You can address other tricky structures, such as parallel merge connected with parallel branches, or parallel branches connected with selection branches, by adding an empty step.

2. Merging branches and transfer conditions

Some seemingly complicated branches are the result of bad design. You can simplify them by merging some branches.

As shown below, the designer set a selection branch first, following it by two selection branches. However, simply four selection branches will achieve the same. The original two-level transfer conditions become one level transfer condition.



3. Making use of battery backup function

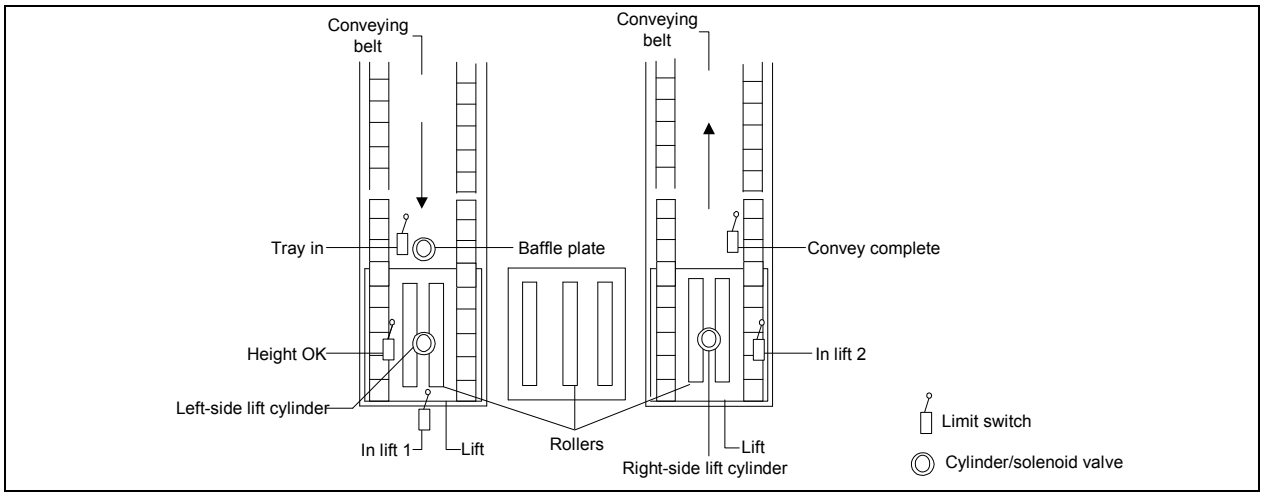
The S elements can be saved upon power failure by the battery. In this way the program can resume from the step when the power failure occurred.

7.5 Examples Of SFC Programming

The examples in this section are just illustrations of SFC programming, with simplified operations and conditions. The equipment configuration is conceptual and for study only. Do not apply the example programs to actual use.

7.5.1 Simple Sequential Structure

The following example is an object lifting and conveying machine. This machine uses cylinder lifting devices and rollers to convey the object tray from one conveying belt to another. The following figure is a top view of the machine.



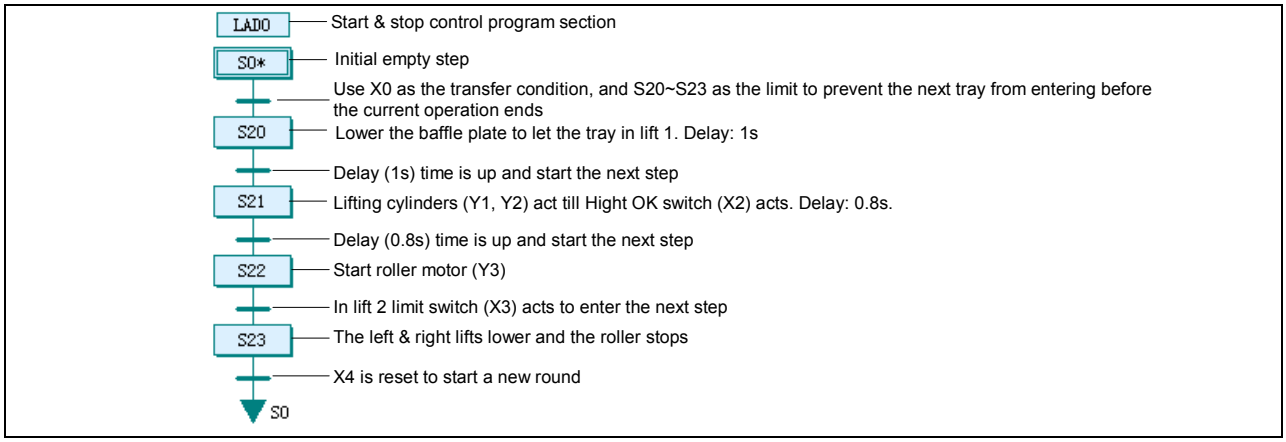
After the machine is started, the object tray will be conveyed to the entrance of the machine at the left side and trigger the “Tray in” limit switch. If no other tray is occupying the machine, the “Baffle plate” will lower down to let the object tray enter the machine. When the tray is completely into the lift when it triggers the “In lift 1” limit switch, the lift will raise the tray until the “Height OK” limit switch is triggered. The rollers will then act to convey the tray to the lift on the right side until the “In lift 2” limit switch is triggered. The lift will then lower to put the tray to the conveying belt on the right. When the “Convey complete” limit switch is reset, a complete lift and convey process is over and the machine is ready for the next round.

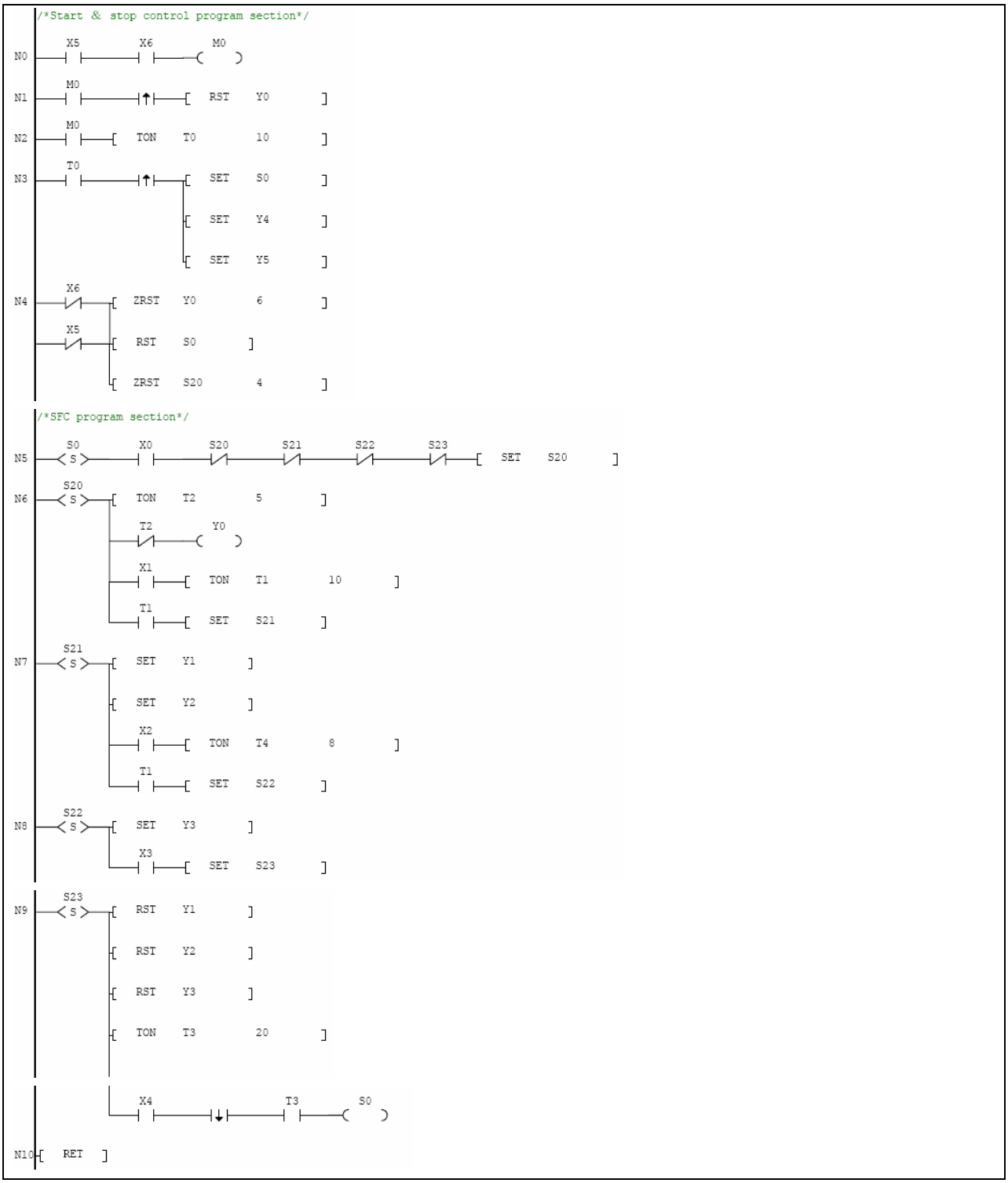
The input and output points are listed in the following table.

SN	Address	Monitored object		SN	Address	Monitored object
1	X0	Tray in limit switch		8	Y0	Cylinder solenoid valve for the baffle plate
2	X1	In lift 1 limit switch		9	Y1	Cylinder solenoid valve for the left lift
3	X2	Height OK limit switch		10	Y2	Cylinder solenoid valve for the right lift
4	X3	In lift 2 limit switch		11	Y3	Roller motor contactor
5	X4	Convey complete		12	Y4	Motor contactor for the left conveying belt
6	X5	Start switch		13	Y5	Motor contactor for the right conveying belt
7	X6	Auxiliary signal of emergency switch				

This is a simple sequential flow. The procedures are linear, without any selection or parallel procedures. Writing the program with SFC would be faster and clearer than the conventional logic design method.

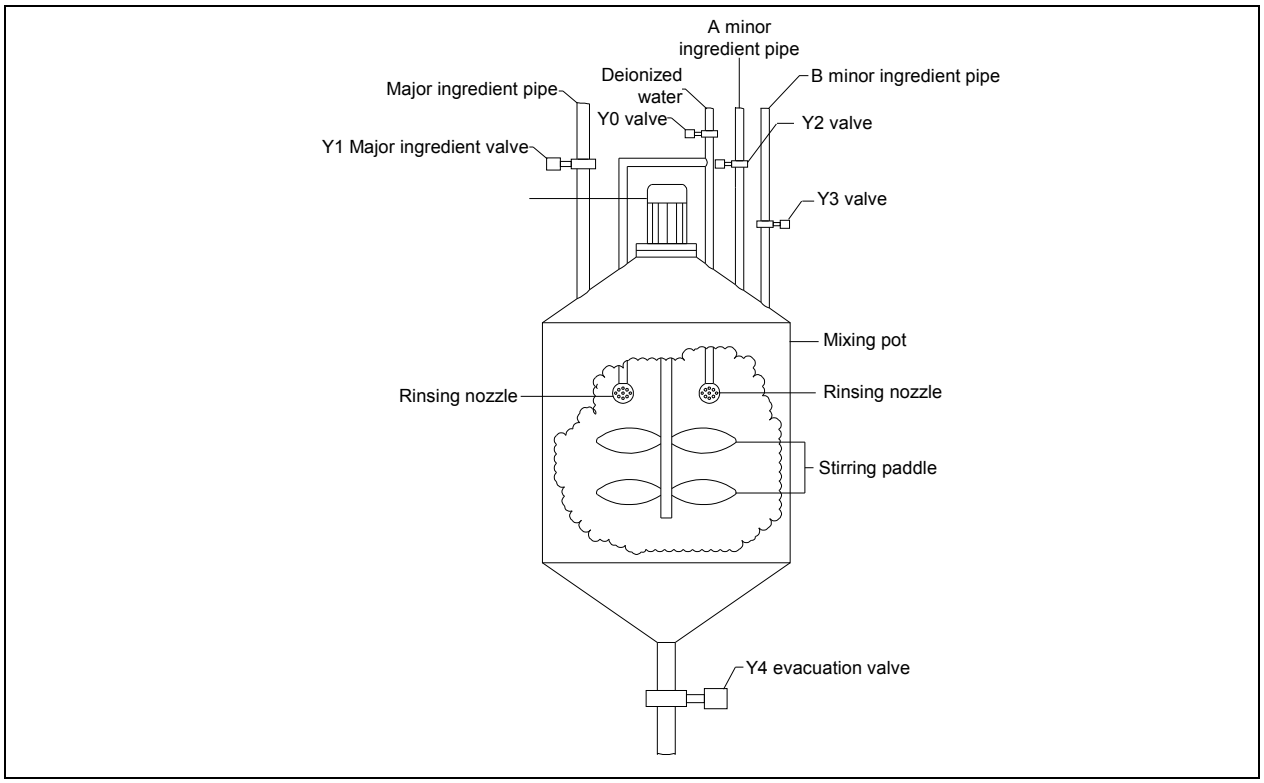
See the following figure for the SFC program and its LAD counterpart.


LAD0
Start & stop control program section
S0*
Initial empty step
Use X0 as the transfer condition, and S20~S23 as the limit to prevent the next tray from entering before the current operation ends
S20
Lower the baffle plate to let the tray in lift 1. Delay: 1s
Delay (1s) time is up and start the next step
S21
Lifting cylinders (Y1, Y2) act till Hight OK switch (X2) acts. Delay: 0.8s.
Delay (0.8s) time is up and start the next step
S22
Start roller motor (Y3)
In lift 2 limit switch (X3) acts to enter the next step
S23
The left & right lifts lower and the roller stops
X4 is reset to start a new round
S0


/*Start & stop control program section*/
N0 X5 X6 M0
N1 M0 RST Y0
N2 M0 TON T0 10
N3 T0 SET S0
SET Y4
SET Y5
N4 X6 ZRST Y0 6
X5 RST S0
ZRST S20 4
/*SFC program section*/
N5 S0 X0 S20 S21 S22 S23 SET S20
N6 S20 TON T2 5
T2 Y0
X1 TON T1 10
T1 SET S21
N7 S21 SET Y1
SET Y2
X2 TON T4 8
T1 SET S22
N8 S22 SET Y3
X3 SET S23
N9 S23 RST Y1
RST Y2
RST Y3
TON T3 20
X4 T3 S0
N10 RET

7.5.2 Selection Branch Structure

The following example is a material mixing flow. Through this flow, two kinds of products, namely A and B, are produced. See the following figure for the illustration of the manufacturing device.



To start the operation, the operator should select through the touch screen the product type, A or B, for the next batch of product. As the second step, the major ingredient wil be added until the added ingredient reaches 2000kg. As the third step, minor ingredient, A for type A product or B for type B product, will be added until the added minor ingredient reaches 500kg. As the forth step, the ingredients will be mixed round for 20 minutes. As the fifth step, the material will be evacuated until the left material is less than 20kg and the delay is over. Then the machine is ready for the next round.

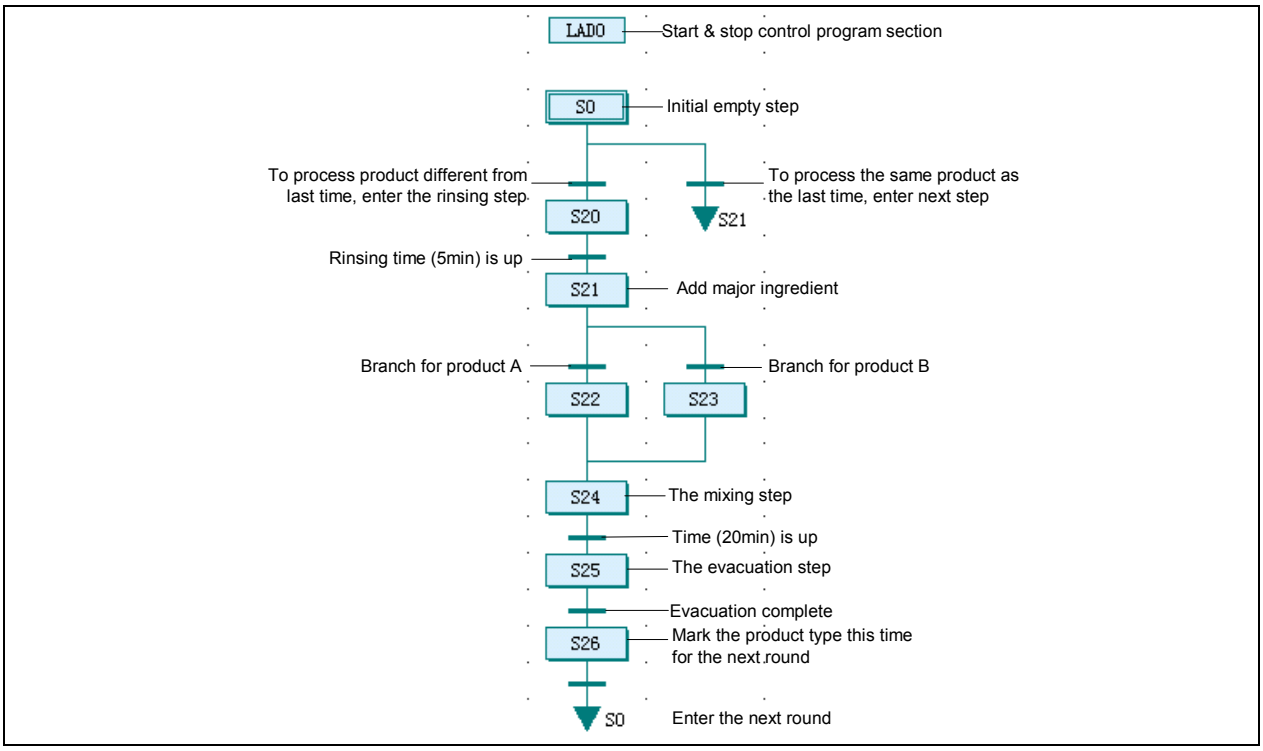
If the machine is brand new, or the product type produced last time is different from what is going to be produced, you need to open the deionized water valve and evacuation valve to rinse the machine for 5 minutes before the operation.

The input and output points are listed in the following table.

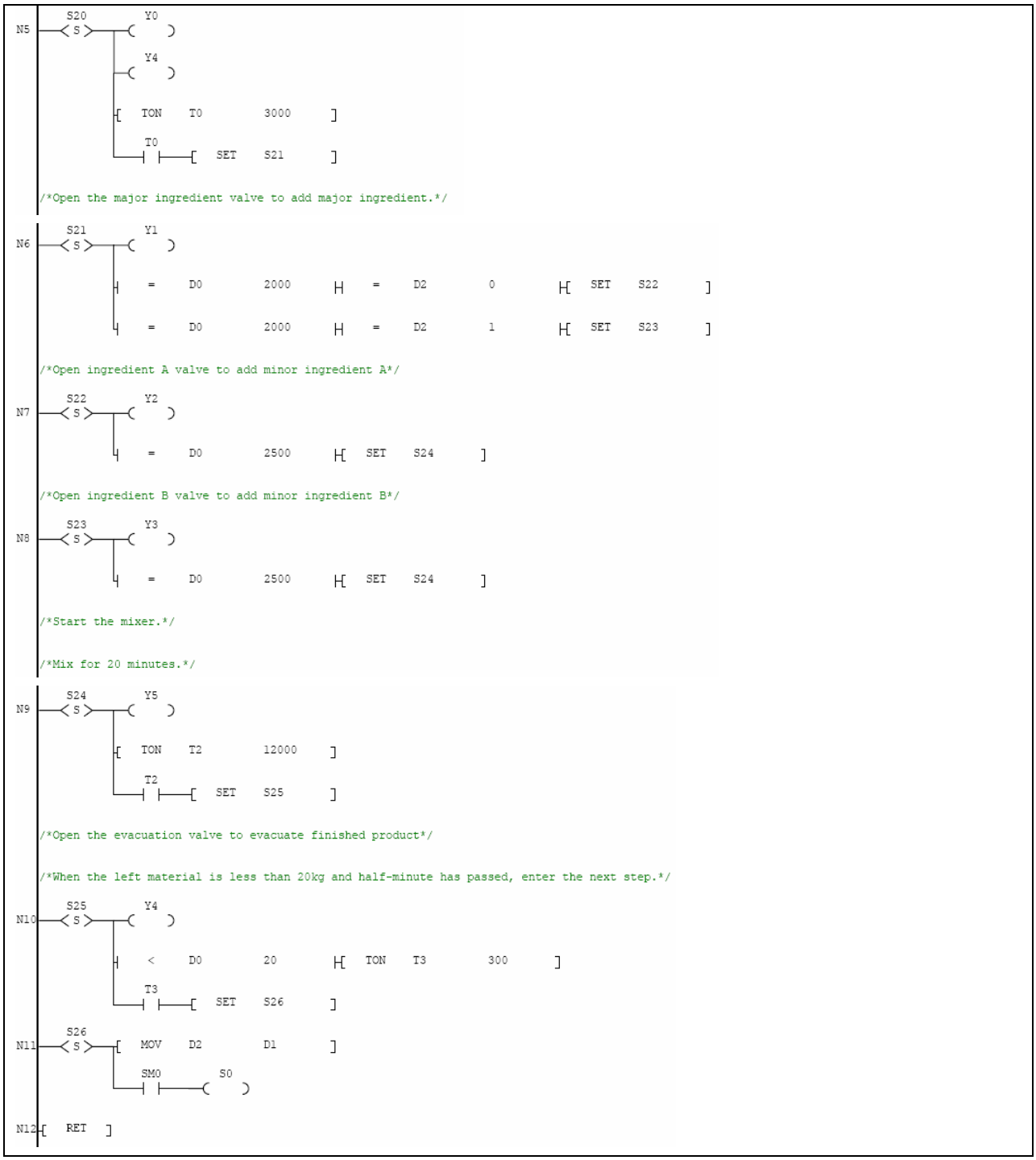
SN	Address	Monitored object		SN	Address	Monitored object
1	X0	Deionized water valve open		10	X11	Evacuation valve open
2	X1	Deionized water valve closed		11	X12	Evacuation valve closed
3	X2	Major ingredient valve open		12	Y0	Solenoid valve for deionized water
4	X3	Major ingredient valve closed		13	Y1	Solenoid valve for major ingredient
5	X4	Minor ingredient A valve open		14	Y2	Solenoid valve for minor ingredient A
6	X5	Minor ingredient A valve closed		15	Y3	Solenoid valve for minor ingredient B
7	X6	Minor ingredient B valve open		16	Y4	Solenoid valve for evacuation
8	X7	Minor ingredient B valve closed		17	Y5	Mixing motor contactor
9	X10	Mixing motor running				

Obviously this is a selection branch structured flow. You can select only one type of product , A or B, in a round. Meanwhile, the flow has a selection and jump structure: the rinsing procedure.

The following figures are the corresponding SFC program and its LAD counterpart.



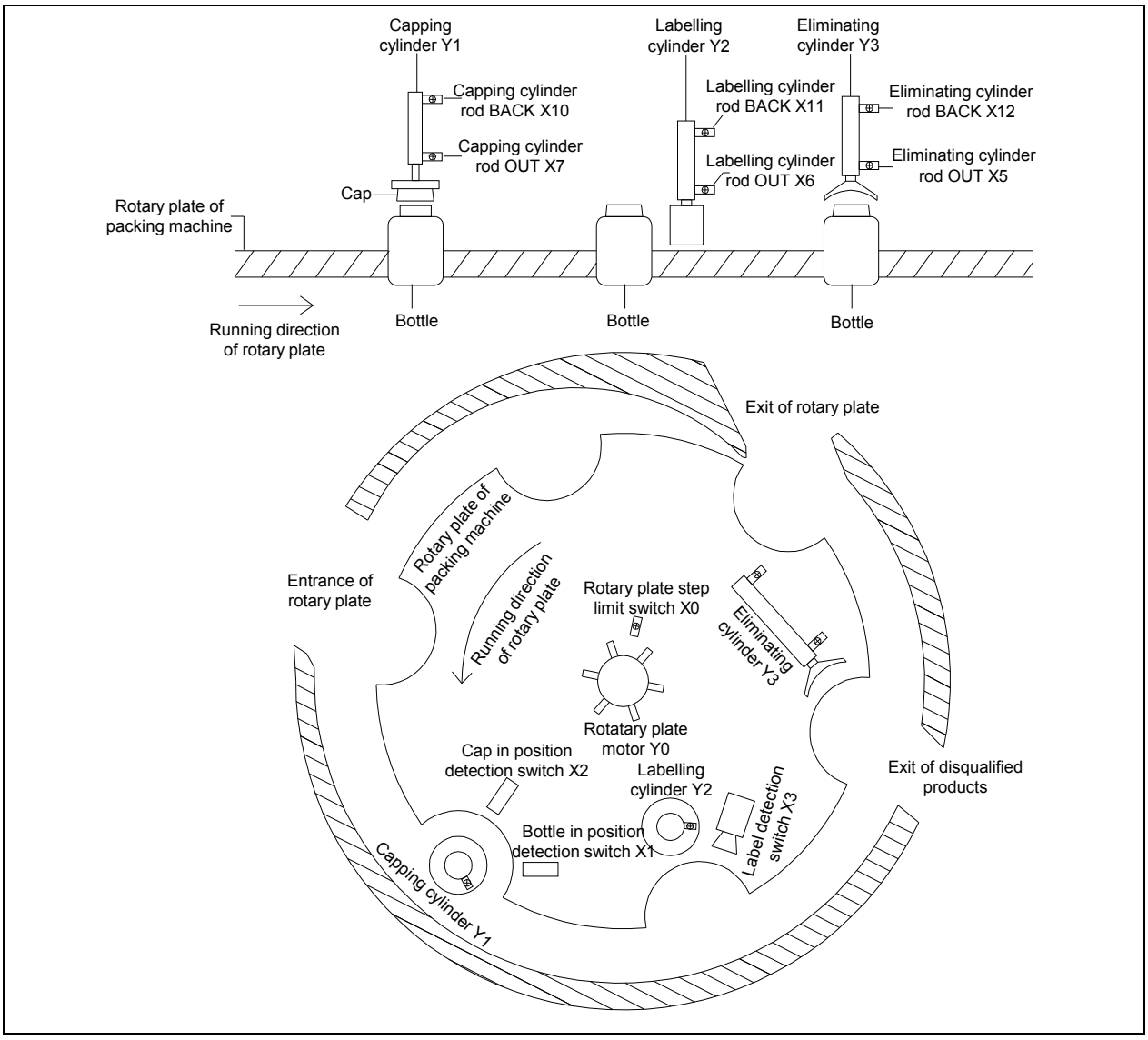

```
/*Reset M1 ~ M3*/

/*D1 stands for the last product. 0: product A. 1: product B.*/

/*D2 stands for the next product. 0: product A. 1: product B.*/

/*M3 is the startup flag.*/

N0   SM1
     |  |--[ MOV   0    D1   ]
     |  |--[ MOV   0    D2   ]
     |  |--[ RST   M3   ]

/*Start operation.*/

N1   X0    X1    M3
     |  |  |  |--( )

N2   M3
     |  |--|↑|--[ SET   S0   ]

/*Stop operation.*/

N3   X0
     |  |--[ ZRST  M1   3    ]
     X1
     |  |--[ RST   S0   ]
     |  |--[ ZRST  S20  7    ]
     |  |--[ ZRST  Y0   6    ]

/*Product selection operation.*/

/*M1 is the screen operation  bit of HMI interface.*/

/*M2 means the two adjacent products are different.*/

N4   S0    M1
     |S|  |  |--|↑|--|  |  <>   D1   D2   H[ SET   M2   ]
     M2
     |  |--[ SET   S20  ]
     M2    S21
     |--|/|--( )
```


N5
S20
S
Y0
Y4
TON T0 3000
T0
SET S21
/*Open the major ingredient valve to add major ingredient.*/
N6
S21
S
Y1
= D0 2000
= D2 0
SET S22
= D0 2000
= D2 1
SET S23
/*Open ingredient A valve to add minor ingredient A*/
N7
S22
S
Y2
= D0 2500
SET S24
/*Open ingredient B valve to add minor ingredient B*/
N8
S23
S
Y3
= D0 2500
SET S24
/*Start the mixer.*/
/*Mix for 20 minutes.*/
N9
S24
S
Y5
TON T2 12000
T2
SET S25
/*Open the evacuation valve to evacuate finished product*/
/*When the left material is less than 20kg and half-minute has passed, enter the next step.*/
N10
S25
S
Y4
< D0 20
TON T3 300
T3
SET S26
N11
S26
S
MOV D2 D1
SM0
S0
N12
RET

7.5.3 Parallel Branch Structure

The next example is a bottle packager. The packager seals the bottles and sticks labels to them. Meanwhile, it will examine the bottle cap and label, so that the flawed products will be eliminated in the third procedure, while the qualified products will continue to the next work flow.

If no bottle is sent from the last work flow, the packager will not conduct any sealing or labelling. The three procedures are carried out at the same time, and each bottle moves from one position to another each time the rotary plate rotates. See the following figure for the illustration of the packager.



During the operation, the rotary plate rotates one step each time, which is detected by the X0 limit switch. The rotary plate will stay at each step long enough for all the three procedures, driven by cylinders, are finished. The cylinder rod OUT signal and cylinder rod BACK signal are monitored respectively.

The input and output points arel isted in the following table.

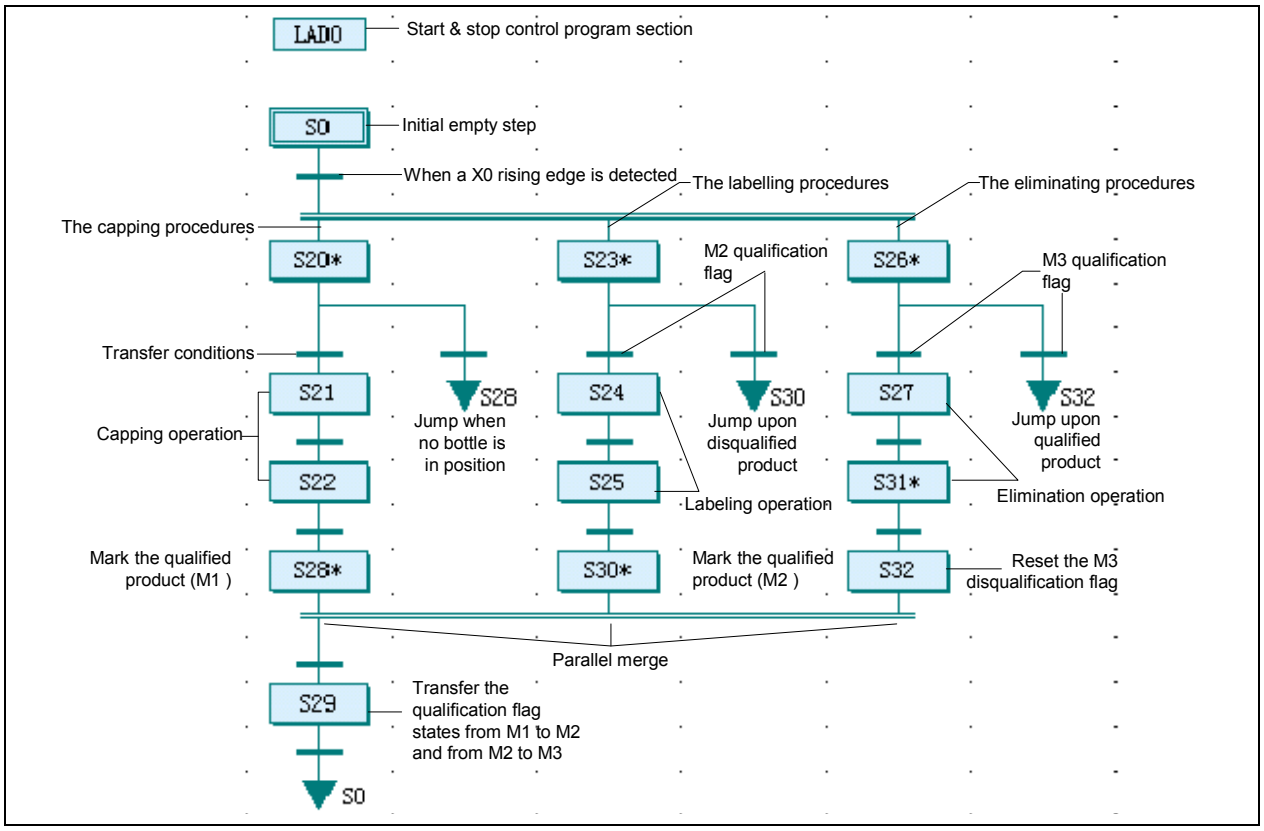
SN	Address	Monitored object		SN	Address	Monitored object
1	X0	Rotary plate step limit switch		8	X10	Capping cylinder rod BACK
2	X1	Bottle in position detection switch		9	X11	Labelling cylinder rod BACK
3	X2	Cap in position detection switch		10	X12	Eliminatiing cylinder rod BACK
4	X3	Label detection switch		11	Y0	Rotary plate motor
5	X5	Eliminating cylinder rod OUT		12	Y1	Capping cylinder
6	X6	Labelling cylinder rod OUT		13	Y2	Labelling cylinder
7	X7	Capping cylinder rod OUT		14	Y3	Eliminating cylinder

It is obvious that this is a parallel branch structured flow. With every step that the rotary plate makes, all the tree procedures are carried out at the same time. Then, when the three procedures are finished, the rotary plate will rotate one step again. See the following figure for the corresponding SFC program and its LAD counterpart.

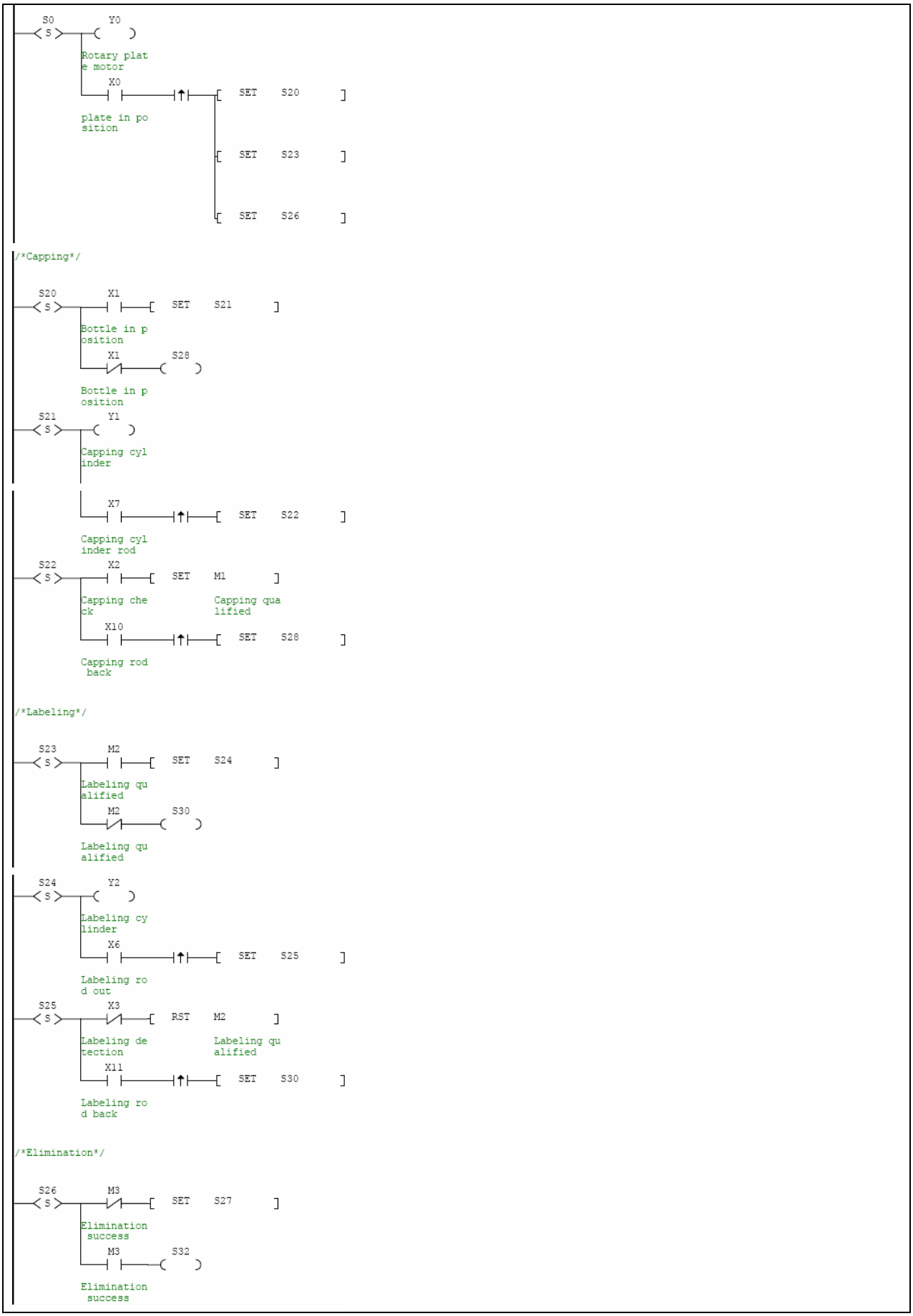
In the program, M1 ~ M3 are the qualification flags for the procedures of capping, labeling and eliminating respectively.

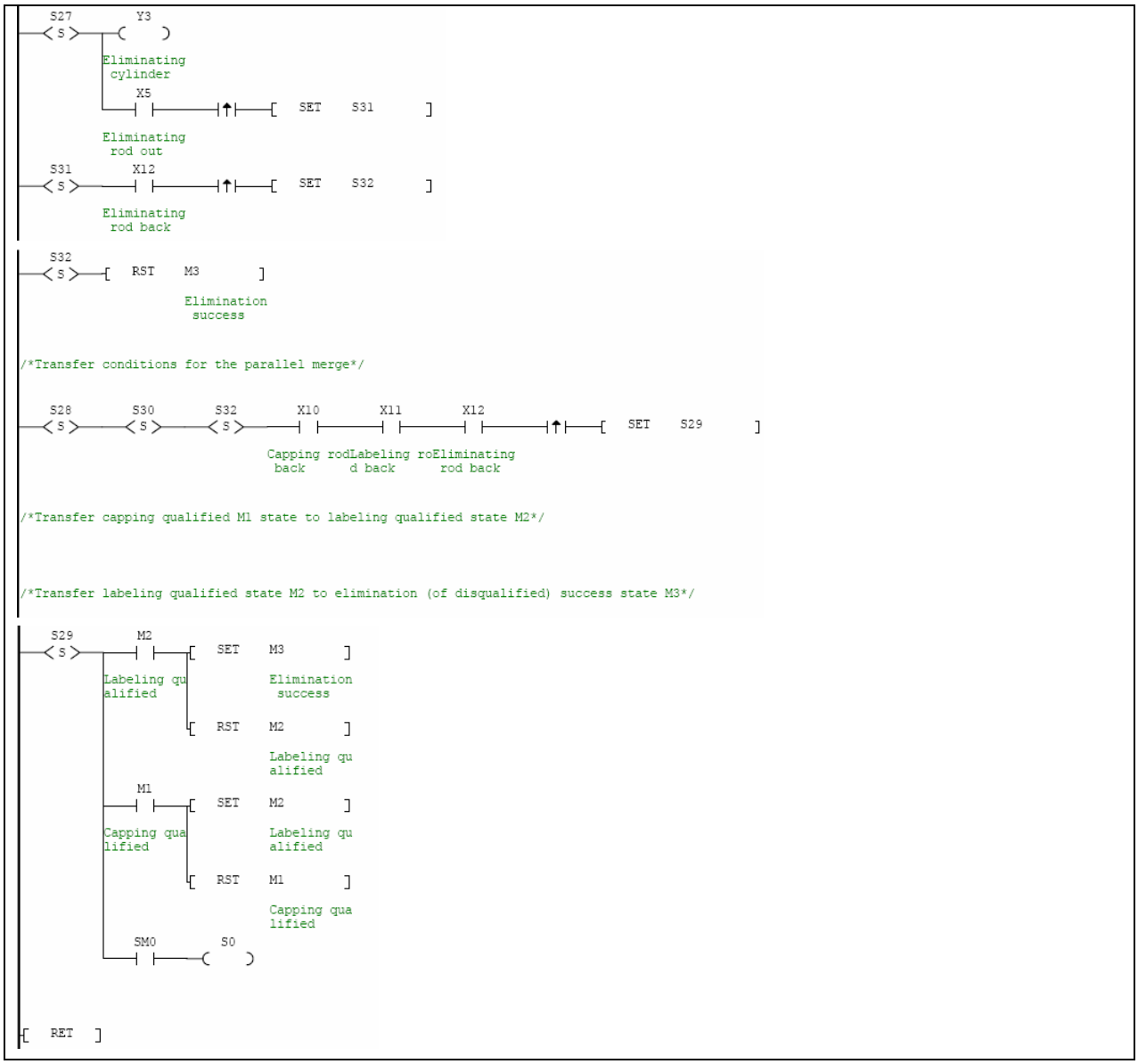
When the capping procedure runs to S22, X2 will check whether the capping is qualified or not. If yes, the corresponding qualification flag M1 will be set. When the labelling procedure runs to S25, X3 will check whether the labelling is qualified or not. If not, M2 will be reset. After all the procedures are complete, at step S29, the M2 state will be transferred to M3, and M1 state will be transferred to M2.

The capping procedure will act according to X1 state. If X1 indicates no bottle is in position, the capping will not proceed. The labelling procedure will act according to M2 state. If M2 is OFF, it indicates that the bottle in position is disqualified, and the labelling will not proceed. The eliminating procedure will act according to M3. The elimination will not be conducted when M3 is ON, which indicates that the bottle is qualified, or the elimination will be conducted otherwise. In both cases, M3 will be reset in S32 to prepare for the next procedure.




```
/*........Start & stop control program section.........*/

    X13                   X14
 ---| |-------------------| |-----[  SET    S0        ]
Start switc              Emergency s
h                        witch
    X13
 ---|/|-------------------[  ZRST   M1        3        ]
Start switc                        Capping qua
h                                  lified
    X14
 ---|/|-------------------[  RST    S0        ]
Emergency s
witch
                          [  ZRST   S20       13       ]



/*.......SFC program section........*/

/*Initial step. Transfer condition: rising edge of X0, indicating rotary plate in position.*/
```


S0
Y0
Rotary plat
e motor
X0
SET S20
plate in po
sition
SET S23
SET S26
/*Capping*/
S20
X1
SET S21
Bottle in p
osition
X1
S28
Bottle in p
osition
S21
Y1
Capping cyl
inder
X7
SET S22
Capping cyl
inder rod
S22
X2
SET M1
Capping che
ck
Capping qua
lified
X10
SET S28
Capping rod
back
/*Labeling*/
S23
M2
SET S24
Labeling qu
alified
M2
S30
Labeling qu
alified
S24
Y2
Labeling cy
linder
X6
SET S25
Labeling ro
d out
S25
X3
RST M2
Labeling de
tection
Labeling qu
alified
X11
SET S30
Labeling ro
d back
/*Elimination*/
S26
M3
SET S27
Elimination
success
M3
S32
Elimination
success


S27
Y3
Eliminating cylinder
X5
SET S31
Eliminating rod out
S31
X12
SET S32
Eliminating rod back
S32
RST M3
Elimination success
/*Transfer conditions for the parallel merge*/
S28
S30
S32
X10
X11
X12
SET S29
Capping rod back
Labeling rod back
Eliminating rod back
/*Transfer capping qualified M1 state to labeling qualified state M2*/
/*Transfer labeling qualified state M2 to elimination (of disqualified) success state M3*/
S29
M2
SET M3
Labeling qualified
Elimination success
RST M2
Labeling qualified
M1
SET M2
Capping qualified
Labeling qualified
RST M1
Capping qualified
SM0
S0
RET

Chapter 8 Using High Speed I/O

This chapter presents the usage and notes about the high speed counters, external pulse and PLS envelope.

8.1 High Speed Counter....227
8.1.1 Configuration....227
8.1.2 High Speed Counter And SM Auxiliary Relay Relationship....228
8.1.3 Usage Of High Speed Counter....228
8.1.4 Points To Note About High Speed Counters....230
8.2 External Pulse Capture Function....231
8.3 High Speed Pulse Output....231
8.3.1 High Speed Pulse Output Function....231
8.3.2 Points To Note About High Speed Pulse Output....231
8.4 Configuring PLS Envelope Instruction....232
8.5 Notes On High Speed I/O Application....234

8.1 High Speed Counter

8.1.1 Configuration

The built-in high speed counter for IVC series small PLCs are configured as follows:

Table 8-1 High speed counter configuration

Counter \ Input point		X0	X1	X2	X3	X4	X5	X6	X7	Max. frequency (kHz)
1 phase & 1 point input mode	Counter236	U/D*								50
	Counter237		U/D							50
	Counter238			U/D						10
	Counter 239				U/D					
	Counter 240					U/D				
	Counter 241						U/D			
	Counter 242	U/D		Reset						
	Counter 243				U/D		Reset			
	Counter 244	U/D		Reset				Start		
	Counter 245				U/D		Reset		Start	
1 phase bi-directional input mode	Counter 246	U	D							50
	Counter 247	U	D	Reset						10
	Counter 248				U	D	Reset			
	Counter 249	U	D	Reset				Start		
	Counter 250				U	D	Reset		Start	
2 phase input mode	Counter 251	Ph A	Ph B							30
	Counter 252	Ph A	Ph B	Reset						5
	Counter 253				Ph A	Ph B	Reset			
	Counter 254	Ph A	Ph B	Reset				Start		
	Counter 255				Ph A	Ph B	Reset		Start	

Note:
1. U: UP
2. D: Down

In the modes listed in the preceding table, the high speed counters will act according to certain input and handle high speed action according to interrupts. The counting practice is unrelated to the PLC scan cycle.

All the high speed counters are of the 32-bit bi-directional type. According to their different up/down switchover methods, they fall into the following three categories:

Item	1 phase I point input	1 phase bi-directional input	2-phase input
Counting direction control	Counters C236 ~ C245 are down counters when SM236 ~ SM245 are ON, and up counters when C236 ~ C245 are off	Counters C246 ~ C250 are either up counters or down counters, dependent on the input	Counter C251 ~ C255 acts according to the input. They count up when phase A is on and phase B changes from OFF to ON, and count down when phase A is ON and phase B changes from ON to OFF
Counting direction flag		SM246 ~ SM255 are the direction flags of C246 ~ C255. SM element OFF: counting up. SM element ON: counting down.	

8.1.2 High Speed Counter And SM Auxiliary Relay Relationship

Special auxiliary relay for controlling counting direction

Type	Counter SN	Up/Down control
1 phase 1 point input	C236	SM236
	C237	SM237
	C238	SM238
	C239	SM239
	C240	SM240
	C241	SM241
	C242	SM242
	C243	SM243
	C244	SM244
	C245	SM245

Special auxiliary relay for monitoring counting direction

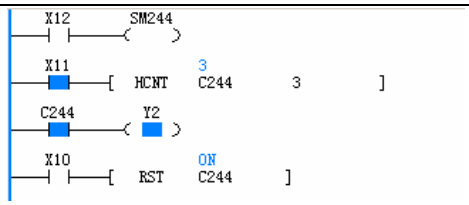
Type	Counter SN	Up/Down monitor
1 phase bi-directional input	C246	SM246
	C247	SM247
	C248	SM248
	C249	SM249
	C250	SM250
2 phase input	C251	SM251
	C252	SM252
	C253	SM253
	C254	SM254
	C255	SM255

8.1.3 Usage Of High Speed Counter

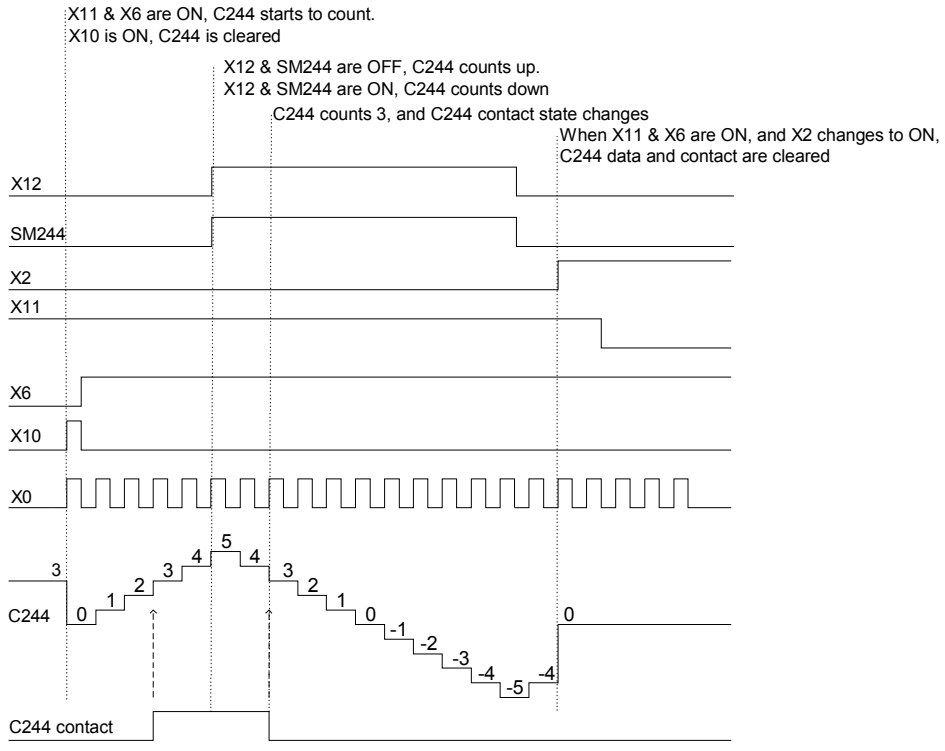
1 phase 1 point input high speed counter

The 1 phase 1 point input high speed counter starts to count only when the pulse input changes from OFF to ON, with the counting direction determined by its corresponding SM element.

Example:



The time sequence chart of the contacts action in the program is shown in the following figure:

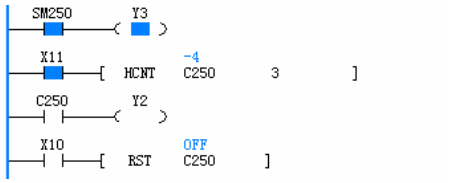

X11 & X6 are ON, C244 starts to count.
X10 is ON, C244 is cleared
X12 & SM244 are OFF, C244 counts up.
X12 & SM244 are ON, C244 counts down
C244 counts 3, and C244 contact state changes
When X11 & X6 are ON, and X2 changes to ON,
C244 data and contact are cleared
X12
SM244
X2
X11
X6
X10
X0
C244
C244 contact

Note:
1. Counter input point: X0.
2. High speed counters, when used in instructions DHSCS, DHSCR, DHSZ, DHSP and DHST, can trigger operations free from the scan cycle.

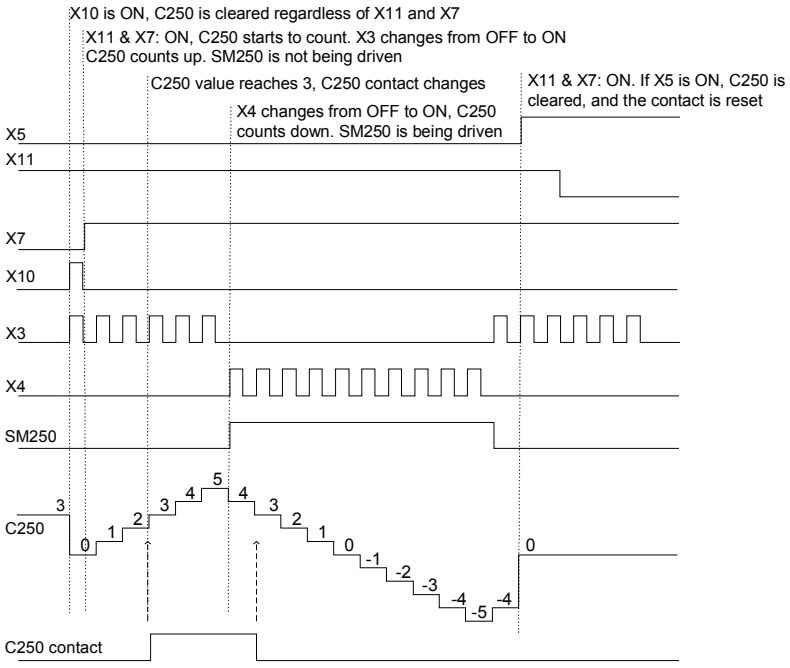
1 phase bi-directional input high speed counter

The 1 phase bi-directional input high speed counter starts to count only when the pulse input changes from OFF to ON. The two input points determines its counting direction, which is monitored by its corresponding SM element.

Example:



The time sequence chart of the contacts action in the program is shown in the following figure:

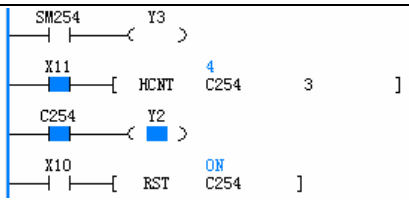

X10 is ON, C250 is cleared regardless of X11 and X7
X11 & X7: ON, C250 starts to count. X3 changes from OFF to ON
C250 counts up. SM250 is not being driven
C250 value reaches 3, C250 contact changes
X4 changes from OFF to ON, C250 counts down. SM250 is being driven
X11 & X7: ON. If X5 is ON, C250 is cleared, and the contact is reset
X5
X11
X7
X10
X3
X4
SM250
C250
C250 contact

Note:
1. Counter input points: X3 & X4.
2. High speed counters, when used in instructions DHSCS, DHSCR, DHSZ, DHSP and DHST, can trigger operations free from the scan cycle.

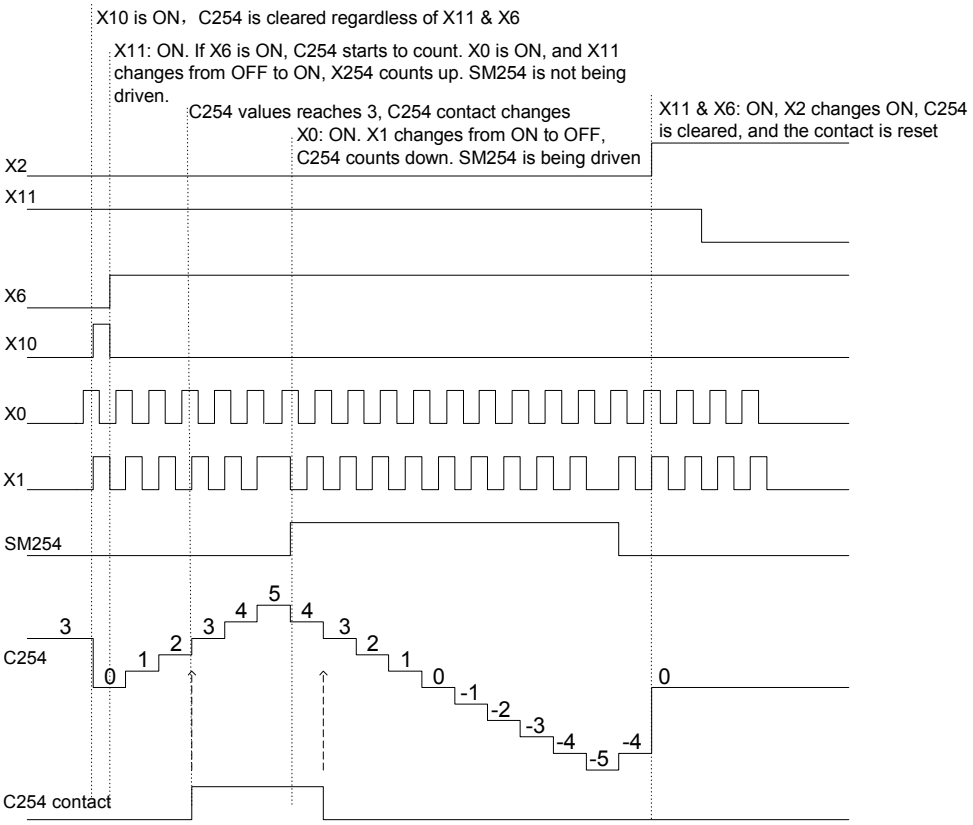
2 phase input high speed counter

The 2 phase input high speed counter starts to count only when the pulse input changes from OFF to ON. The phase difference of the two pulse inputs determines the counting direction, which is monitored by the corresponding SM element.

Example:



The time sequence chart of the contacts action in the program is shown in the following figure:


X10 is ON，C254 is cleared regardless of X11 & X6
X11: ON. If X6 is ON, C254 starts to count. X0 is ON, and X11 changes from OFF to ON, X254 counts up. SM254 is not being driven.
C254 values reaches 3, C254 contact changes
X0: ON. X1 changes from ON to OFF, C254 counts down. SM254 is being driven
X11 & X6: ON, X2 changes ON, C254 is cleared, and the contact is reset
X2
X11
X6
X10
X0
X1
SM254
C254
C254 contact
Note:
1. Counter input points: X0 & X1.
2. High speed counters, when used in instructions DHSCS, DHSCR, DHSZ, DHSP and DHST, can trigger operations free from the scan cycle.

8.1.4 Points To Note About High Speed Counters

Classification of high speed counters

C236, C237, C246 and C251 can be used as both hardware counters and software counters, depending on the modes in which they are used. All the other high speed counters are software counters.

Maximum combined frequency

1. The maximum combined frequency, or the sum of frequencies of all signals input at any time, should not exceed 80kHz on the following two occasions:

- When multiple high speed counters (hardware counting mode) are used simultaneously.
- When the high speed counters (hardware counting mode) and the SPD instruction are used at the same time.

2. The maximum combined frequency when multiple software high speed counters, or when high speed counters and the SPD instruction, are used at the same time, is shown in the following table:

Scenario	Maximum combined frequency
Instructions DHSCS, DHSCR, DHSCI, DHSZ, DHSP and DHST are not used	80kHz
Instructions DHSCS, DHSCR, DHSCI, DHSP or DHST are used	30kHz
Instruction DHSZ is used	20kHz

Maximum frequency of hardware counter

Counters C236, C237, C246 and C251 are the only four potential hardware counters. Among which:

- C236, C237 and C246 are 1 phase counters. Their maximum counting frequency is 50kHz.
- C251 is a 2-phase counter. Its maximum counting frequency is 30kHz.

Maximum frequency of software counters

The high speed counters used in instructions DHSCS, DHSCR, DHSCI, DHSP or DHST are all in software counting mode. The maximum input frequency for the 1-phase counters is 10kHz; for 2-phase counters: 5kHz.

When used in the DHSZ instruction, the maximum frequency for the 1-phase counters is 5kHz; for 2-phase counters: 4kHz.

8.2 External Pulse Capture Function

The input points that provides the external pulse capture function are X0 ~ X7. The corresponding SM elements are listed below:

Input point	Corresponding SM element
X0	SM90
X1	SM91
X2	SM92
X3	SM93
X4	SM94
X5	SM95
X6	SM96
X7	SM97

Note

1. When the output input point changes from OFF to ON, the SM element of the corresponding terminal will be set to ON.
2. SM90 ~ SM97 will be cleared when the user program starts.
3. The total pulse frequency input through X0 ~ X7 should be smaller than 80kHz.
4. If high speed counters or SPD instructions are used on the same input point, the pulse capture function will become invalid after the first scan cycle, regardless of the validity of the instructions.

8.3 High Speed Pulse Output

8.3.1 High Speed Pulse Output Function

The high speed pulse output is the pulse controllable with instructions PLSY, PLSR, PLS and PWM, and output through Y0 or Y1. See *6.10 High-speed I/O Instruction* for the usage of such instructions.

The pulse output is unrelated to the scan cycle.

Using two PLSY, PWM or PLSR instructions at the same time can output two independent high speed pulses at Y0 and Y1.

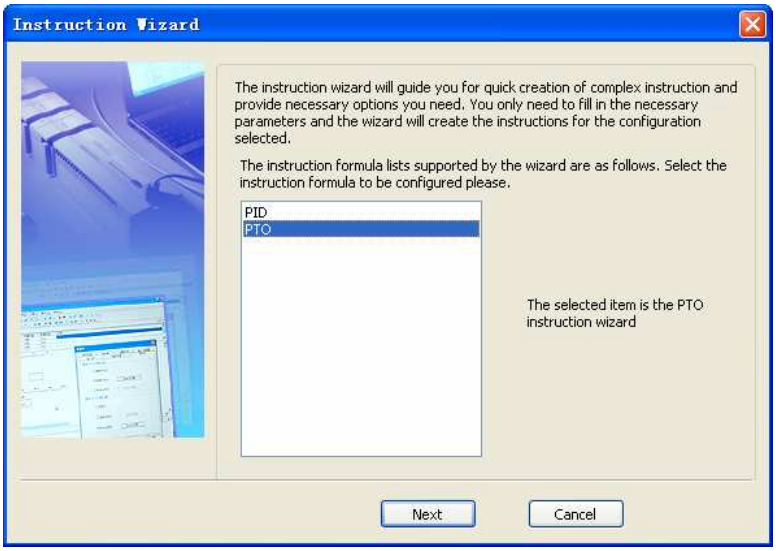
8.3.2 Points To Note About High Speed Pulse Output

During the execution of the high-speed instruction, so long as the power flow is not OFF, no other instructions can use the same port, unless the high speed pulse output instruction is invalid.

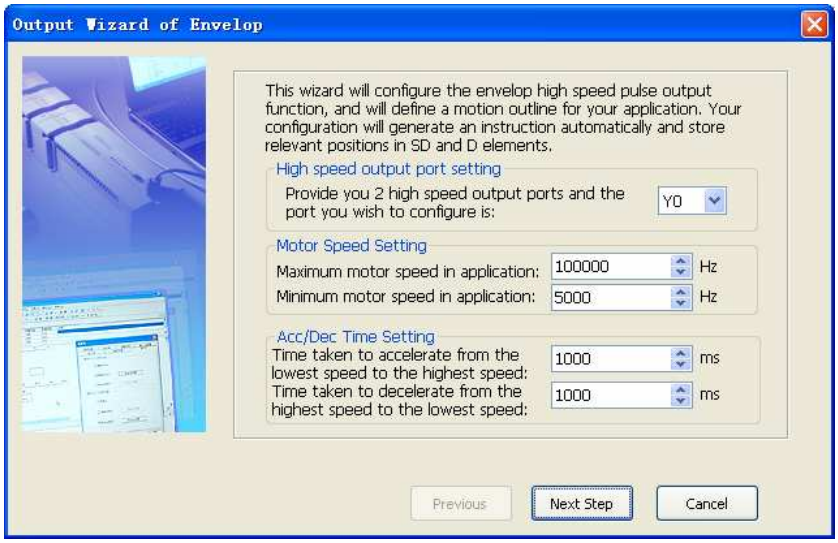
If multiple PWM, PLSY or PLSR instructions uses the same output point, the output point will be available only to the first valid instruction.

8.4 Configuring PLS Envelope Instruction

You can use the PTO instruction wizard to generate a PLS envelope instruction. In the AutoStation main interface, select **Tool** -> **Instruction Wizard** … to open the dialogue box as shown in the following figure.


Instruction Wizard
The instruction wizard will guide you for quick creation of complex instruction and provide necessary options you need. You only need to fill in the necessary parameters and the wizard will create the instructions for the configuration selected.
The instruction formula lists supported by the wizard are as follows. Select the instruction formula to be configured please.
PID
PTO
The selected item is the PTO instruction wizard
Next
Cancel

Select **PTO**, and click the **Next** button to enter the **Output Wizard of Envelop**, as shown in the following figure.


Output Wizard of Envelop
This wizard will configure the envelop high speed pulse output function, and will define a motion outline for your application. Your configuration will generate an instruction automatically and store relevant positions in SD and D elements.
High speed output port setting
Provide you 2 high speed output ports and the port you wish to configure is:
Y0
Motor Speed Setting
Maximum motor speed in application:
100000
Hz
Minimum motor speed in application:
5000
Hz
Acc/Dec Time Setting
Time taken to accelerate from the lowest speed to the highest speed:
1000
ms
Time taken to decelerate from the highest speed to the lowest speed:
1000
ms
Previous
Next Step
Cancel

All the sections of the envelope have the same acceleration and deceleration. For example, according to the configuration shown in the preceding figure, the time it takes for the motor to accelerate from 20000Hz to 50000Hz is:

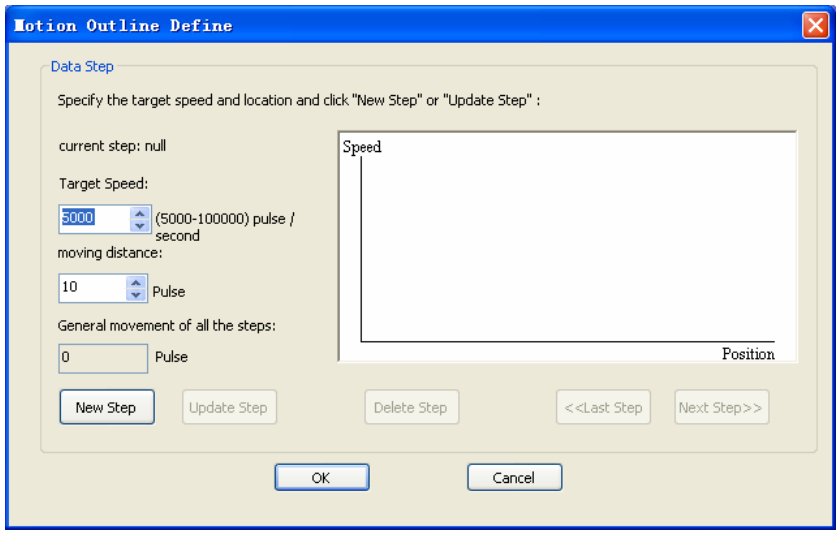
1000 × (50000 - 20000) ÷ (100000 - 5000) = 316 (ms) = 0.316 (s)

During the acceleration, the total pulse number can be figured out with the trapezoid area calculation method:

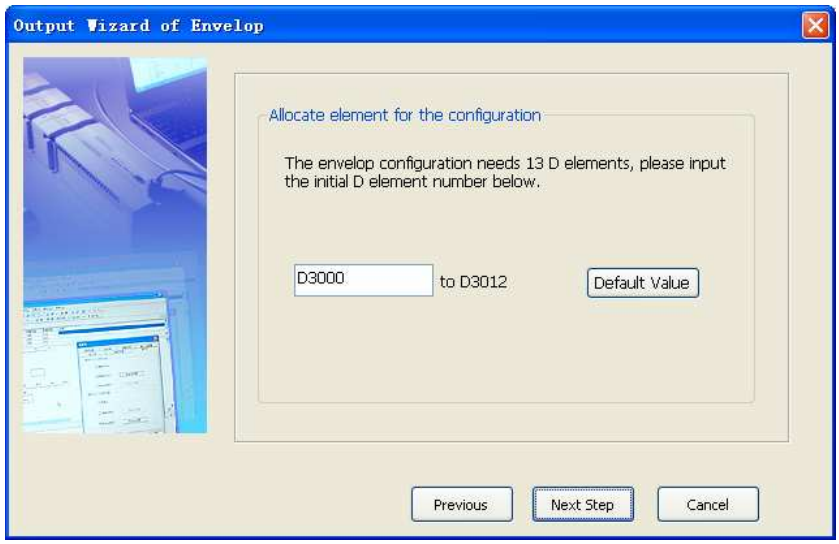
(20000+50000) ×0.316÷2 = 11060 (pulse number)

Therefore, if a certain accerleration/deceleration time or pulse number is required, you should do the math before setting the maximum speed, minimum speed and acc./dec. time.

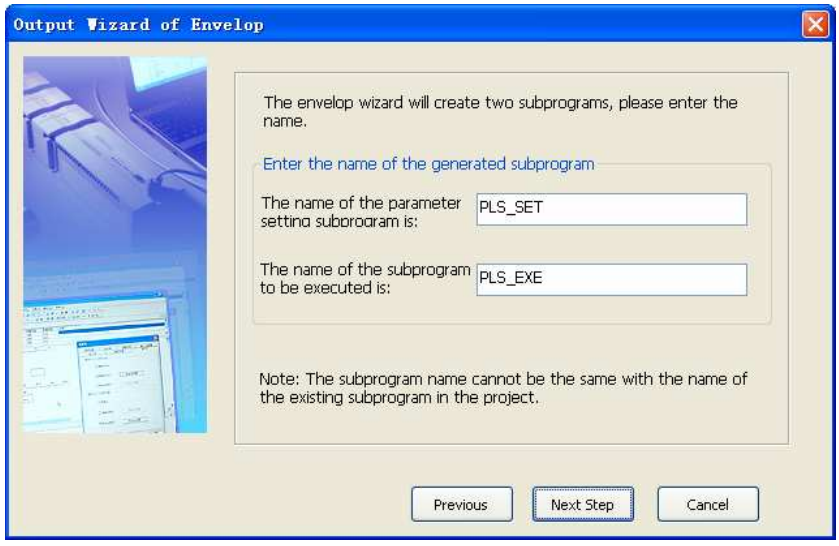
Click the **Next Step** button in the preceding figure to enter the **Motion Outline Define** window as shown in the following figure.



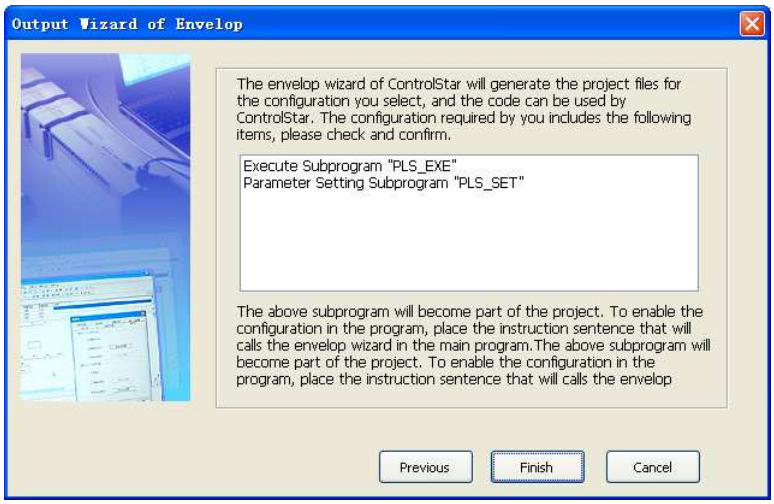
Input the **Target Speed** and **moving distance** of the first step, and click the **New Step** button. Then input the **Target Speed** and **moving distance** again and click the **New Step** button again. Repeat this operation until no more steps are needed. Then you can click the **OK** button to enter the **Output Wizard of Envelop**, as shown in the following figure, where you can save the configuration into D elements.



The wizard will generate two subprograms, one for setting the parameters, the other for executing the PLS instruction, as shown in the following figure. During the programming, do not call the execution subprogram before the parameter setting subprogram has been called and executed (to assigned values to D elements).


Output Wizard of Envelop
The envelop wizard will create two subprograms, please enter the name.
Enter the name of the generated subprogram
The name of the parameter setting subprogram is:
PLS_SET
The name of the subprogram to be executed is:
PLS_EXE
Note: The subprogram name cannot be the same with the name of the existing subprogram in the project.
Previous
Next Step
Cancel

After naming the subprograms, click the **Next Step** button to enter the window as shown in the following figure:


Output Wizard of Envelop
The envelop wizard of ControlStar will generate the project files for the configuration you select, and the code can be used by ControlStar. The configuration required by you includes the following items, please check and confirm.
Execute Subprogram "PLS_EXE"
Parameter Setting Subprogram "PLS_SET"
The above subprogram will become part of the project. To enable the configuration in the program, place the instruction sentence that will calls the envelop wizard in the main program.The above subprogram will become part of the project. To enable the configuration in the program, place the instruction sentence that will calls the envelop
Previous
Finish
Cancel

Click the **Finish** button to complete the PTO configuration.

8.5 Notes On High Speed I/O Application

The input points X0 ~ X7 can input signals for functions including high speed counter, SPD, pulse capture and external interrupt. However, such functions cannot be used at the same time, for the chances are that several functions could require the same input point(s). Therefore, during the PLC programming, only one of the several functions that an input point can provide is available. If X0 ~ X7 are repeatedly used in a user program, the program will not pass the compiling.

Among the functions of high speed counter, SPD, pulse capture and external interrupt, the function that X0 ~ X7 can provide respectively are listed in the following table.

Counter \ Input point		X0	X1	X2	X3	X4	X5	X6	X7	Max. frequency (kHz)
1 phase & 1 point input mode	Counter236	U/D*								50
	Counter237		U/D							50
	Counter238			U/D						10
	Counter 239				U/D					
	Counter 240					U/D				
	Counter 241						U/D			
	Counter 242	U/D		Reset						
	Counter 243				U/D		Reset			
	Counter 244	U/D		Reset				Start		
	Counter 245				U/D		Reset		Start	
1 phase bi-directional input mode	Counter 246	U	D							50
	Counter 247	U	D	Reset						10
	Counter 248				U	D	Reset			
	Counter 249	U	D	Reset				Start		
	Counter 250				U	D	Reset		Start	
2 phase bi-directional mode	Counter 251	Ph A	Ph B							30
	Counter 252	Ph A	Ph B	Reset						5
	Counter 253				Ph A	Ph B	Reset			
	Counter 254	Ph A	Ph B	Reset				Start		
	Counter 255				Ph A	Ph B	Reset		Start	
SPD instruction		Input point	Input point	Input point	Input point	Input point	Input point			10
Pulse capture function		Input point	Input point	Input point	Input point	Input point	Input point	Input point	Input point	
External interrupts SN (rising/trailing edge)		0/10	1/11	2/12	3/13	4/14	5/15	6/16	7/17	
Note: U: UP; D: Down										

Chapter 9 Using Interrupts

This chapter details the mechanism, processing procedures and usage of various interrupts.

9.1 Interrupt Program 236
9.2 Processing Interrupt Event 236
9.3 Timed Interrupt 237
9.4 External Interrupt 238
9.5 High-speed Counter Interrupt 240
9.6 PTO Output Completion Interrupt 241
9.7 Power Failure Interrupt 242
9.8 Serial Port Interrupt 242

9.1 Interrupt Program

When an interrupt event occurs, the normal scan cycle will be interrupted and the interrupt program will be executed, which is called the interrupt mechanism. For the event-triggered control tasks that requires priority, you often need to use this special mechanism.

The system provides many kinds of programmable interrupt resources. Each kind of interrupt resource can trigger a type of interrupt events, and each type of interrupt event are independently numbered.

In order to deal with a certain interrupt event, you must compile a processing program, that is, an interrupt program, which is an independent POU in the user program.

An event number must be designated for each interrupt program in order to link the interrupt program with the interrupt event designated with the event SN. When responding to the interrupt request of the interrupt event, the system will call the corresponding interrupt program based on the interrupt event number.

The following are the interrupt resources provided by IVC series small PLC:

Event number	Interrupt event	Enabling SM		Event number	Interrupt event	Enabling SM
0	X0 input rising edge interrupt	SM40		20	High-speed counter interrupt 0	SM65
1	X1input rising edge interrupt	SM41		21	High-speed counter interrupt 1	SM65
2	X2 input rising edge interrupt	SM42		22	High-speed counter interrupt 2	SM65
3	X3 input rising edge interrupt	SM43		23	High-speed counter interrupt 3	SM65
4	X4 input rising edge interrupt	SM44		24	High-speed counter interrupt 4	SM65
5	X5 input rising edge interrupt	SM45		25	High-speed counter interrupt 5	SM65
6	X6 input rising edge interrupt	SM46		26	Timed interrupt 0	Setting: SD66 Enabling: SM66
7	X7 input rising edge interrupt	SM47		27	Timed interrupt 1	Setting: SD67 Enablin: SM67
10	X0 input falling edge interrupt	SM40		28	Timed interrupt 2	Setting: SD68 Enabling: SM68
11	X1 input falling edge interrupt	SM41		29	Power failure interrupt	SM56
12	X2 input falling edge interrupt	SM42		30	Character sending interrupt of communication port 0	SM48
13	X3 input falling edge interrupt	SM43		31	Character receiving interrupt of communication port 0	SM49
14	X4 input falling edge interrupt	SM44		32	Frame sending interrupt of communication port 0	SM50
15	X5 input falling edge interrupt	SM45		33	Frame receiving interrupt of communication port 0	SM51
16	X6 input falling edge interrupt	SM46		34	Character sending interrupt of communication port 1	SM52
17	X7 input falling edge interrupt	SM47		35	Character receiving interrupt of communication port 1	SM53
18	PTO (Y0) output completion interrupt	SM63		36	Frame sending interrupt of communication port 1	SM54
19	PTO (Y1) output completion interrupt	SM64		37	Frame receiving interrupt of communication port 1	SM55

9.2 Processing Interrupt Event

1. When a certain interrupt event occurs, if it is enabled, its corresponding event number will be added to the interrupt request queue, which is 8-record long and FIFO.

2. Processing of the interrupt request by system:

1) If the system detects that any request in the interrupt queue, it will stop the normal execution of user program.

2) The system will read in the request queue the head record, which is the number of the first interrupt event. The interrupt program corresponding to the event number will be called and executed.

3) When the interrupt program is finished, the corresponding head record of the request queue will be deleted, and all the following records will take one step foward.

4) The system will repeat these procedures until the queue is empty.

5) When the interrupt request queue is null, the system will continue to execute the interrupted main program.

3. The system can handle only one interrupt request at one time. When the system is processing an interrupt request, a new interrupt event will be added to the interrupt request queue rather than being responded immediately. The system will process it after all the requests ahead of it in the queue are processed.

4. When there are 8 records in the interrupt request queue, the system will automatically mask the new interrupt event so that no new requests will be added to the queue. The mask will not be cancelled until all the requests in the queue are processed and the interrupted main program is executed.

Note

1. The interrupts should be brief, or abnormalities may occur, including the mask of other interrupt events (missing of interrupt requests), system scan overtime and low execution efficiency of main program.
2. It is prohibited to call other subprograms in the interrupt program.
3. If you want to refresh I/O immediately during the interrupt, use the REF instruction. Note that the execution time of REF is related to the number of the I/Os to be refreshed.
4. An interrupt event can generate an interrupt request only when the corresponding interrupt event is enabled (which requires setting the corresponding SM element ON), and the global interrupt enable flag shall be on.
5. When an interrupt request with no corresponding interrupt program in the user program is generated, the request will be responded to, but the response is empty.

9.3 Timed Interrupt

Description

The timed interrupt is the interrupt event generated by the system from time to time based on the user setting.

The timed interrupt program is applicable to the situation that requires timed and immediate processing by the system, such as the timed sampling of analogue signals, and timed updating analogue output according to certain waveform.

You can set the intervals (unit: ms) for the timed interrupts by setting the corresponding SD elements. The system will generate the interrupt eventwhen the set time interval is reached (recommended minimum interval: > 4ms).

The ON/OFF status of certain SM elements can enable/disable the corresponding timed interrupts.

The system provides 3 kinds of timed interrupt resources.

Table 9-1 Timed interrupt resource list

Timed interrupt	Interrupt event number	Intervals of timed interrupt (SD)	Enable control (SM)
0	26	SD66	SM66
1	27	SD67	SM67
2	28	SD68	SM68

Note

1. Setting of enable control elements cannot affect the exection of the timed interrupts in the interrupt request queue.
2. The timing for a re-enabled interrupt will start from zero.

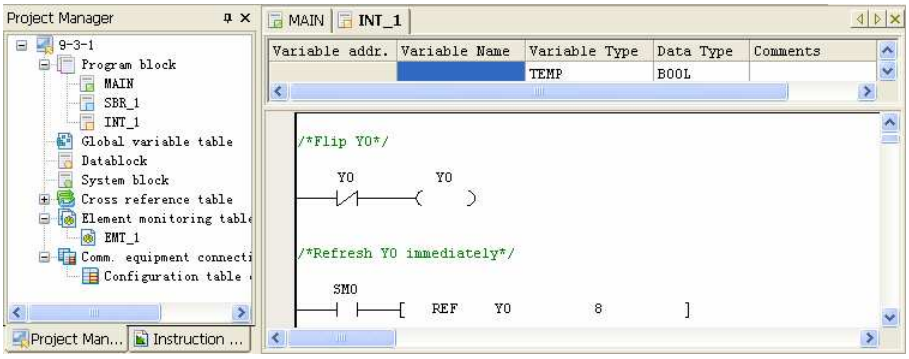
To change the interval of the timed interrupt when the program is running, it is recommended to follow the following procedures:

1. Disable the timed interrupt.
2. Change the interval.
3. Enable the time interrupt.

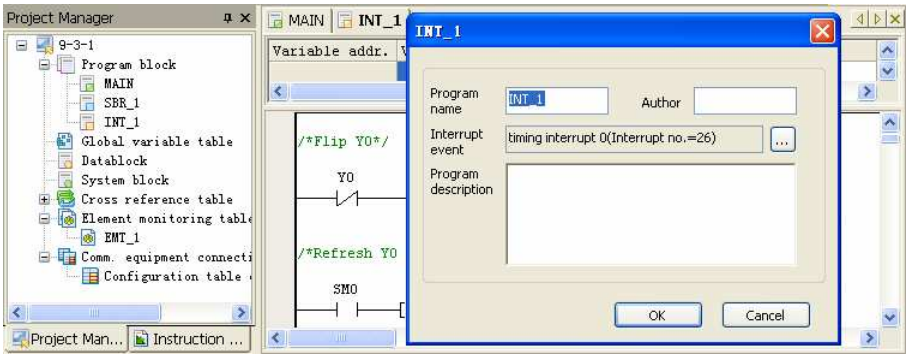
Example

This example uses timed interrupt 0 to flip the Y0 output once a second, which makes Y0 flashe.

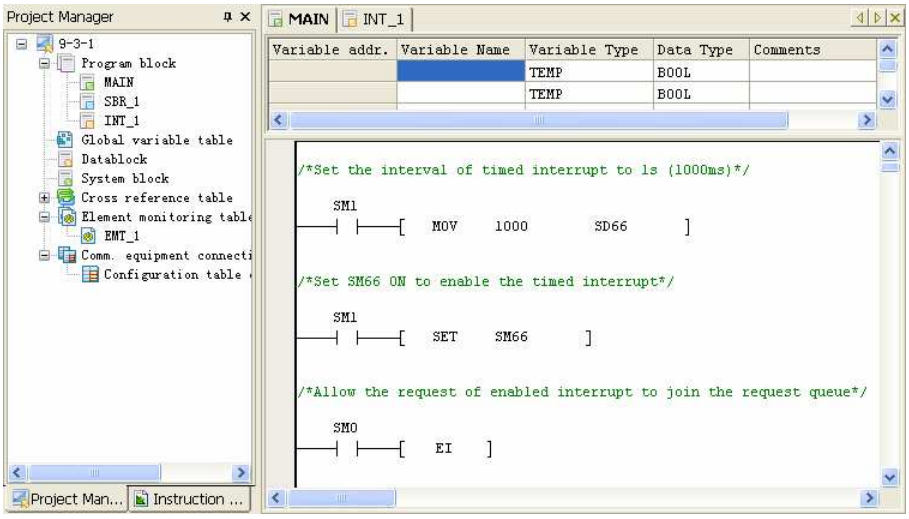
1. Compile an interrupt program for the interrupt event.



2. Specify an interrupt event number for the interrupt program:



3. Set the interval for the timed interrupt and enable the timed interrupt in the main program.



9.4 External Interrupt

Description

The external interrupt is related to the actual PLC input points. It is classified into input rising edge interrupt and input falling edge interrupt. In the user program, add the actions related to external event to the external interrupt program. The highest response frequency of the system to the external event is 1K. The external events over 1K may be lost. The rising edge interrupt and falling edge interrupt cannot be used on the same port simultaneously. All the external interrupts are only valid when the global interrupt control EI and corresponding enabling SM are valid.

The detailed relationship is as follows:

Interrupt number	Enabling element		Interrupt number	Enabling element
0 or 10	SM40		4 or 14	SM44
1 or 11	SM41		5 or 15	SM45
2 or 12	SM42		6 or 16	SM46
3 or 13	SM43		7 or 17	SM47

The external interrupts are numbered as follows:

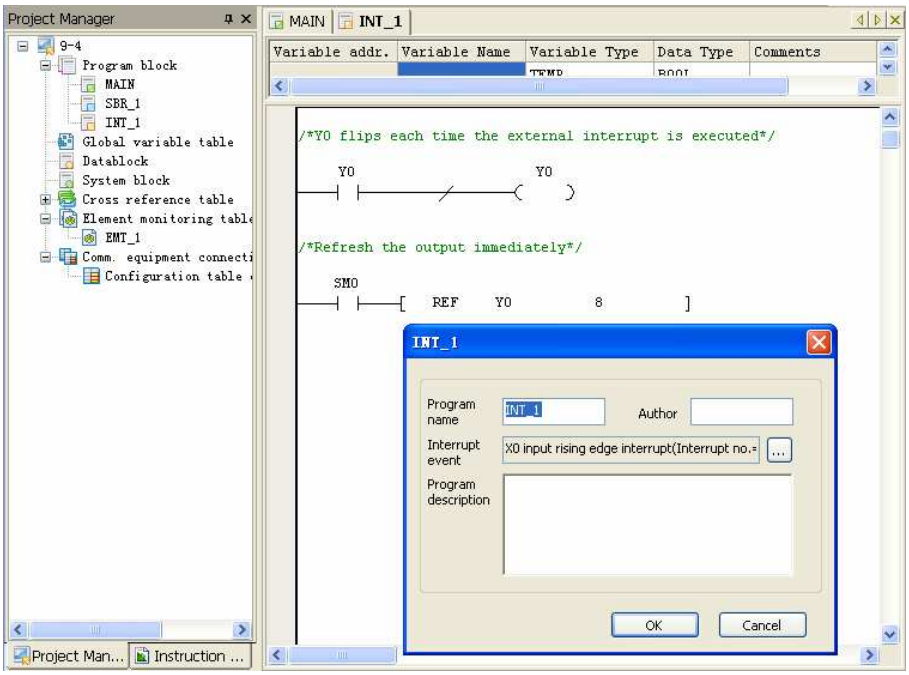
Interrupt number	Interrupt source		Interrupt number	Interrupt source
0	X0 input rising edge interrupt		9	Reserved
1	X1 input rising edge interrupt		10	X0 input falling edge interrupt
2	X2 input rising edge interrupt		11	X1 input falling edge interrupt
3	X3 input rising edge interrupt		12	X2 input falling edge interrupt
4	X4 input rising edge interrupt		13	X3 input falling edge interrupt
5	X5 input rising edge interrupt		14	X4 input falling edge interrupt
6	X6 input rising edge interrupt		15	X5 input falling edge interrupt
7	X7 input rising edge interrupt		16	X6 input falling edge interrupt
8	Reserved		17	X7 input falling edge interrupt

The single input impulse frequency of X0 - X7 is less than 200Hz.

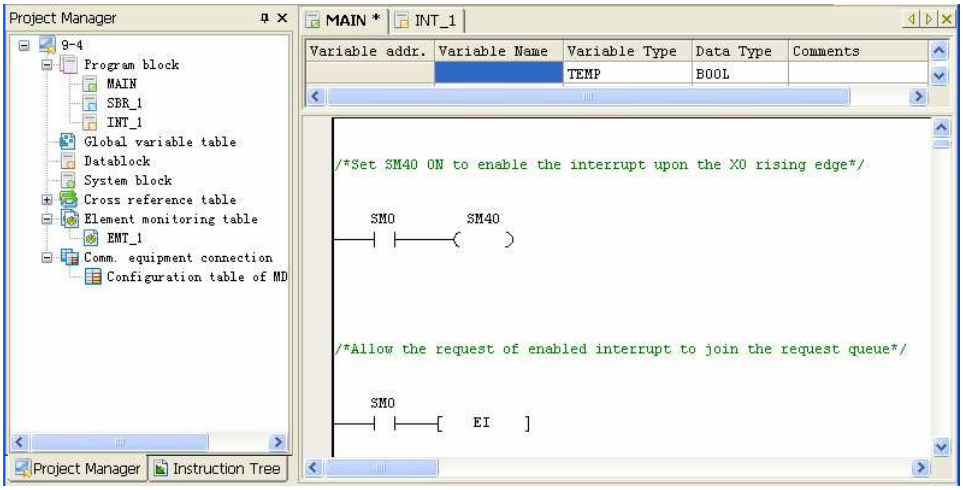
Example

In the example, the system upsets the output of Y0 based on the corresponding external interrupt 0 function and rising edge input event of X0.

1. Compile the interrupt program to flip Y0 status once upon every interrupt and output immediately. To use an interrupt, you should select its corresponding interrupt number. See the following figure for the specific operation.



2. Write EI instruction in the main program, and set SM40, the interrupt enabling flag of X0 input rising edge interrupt, valid.



9.5 High-speed Counter Interrupt

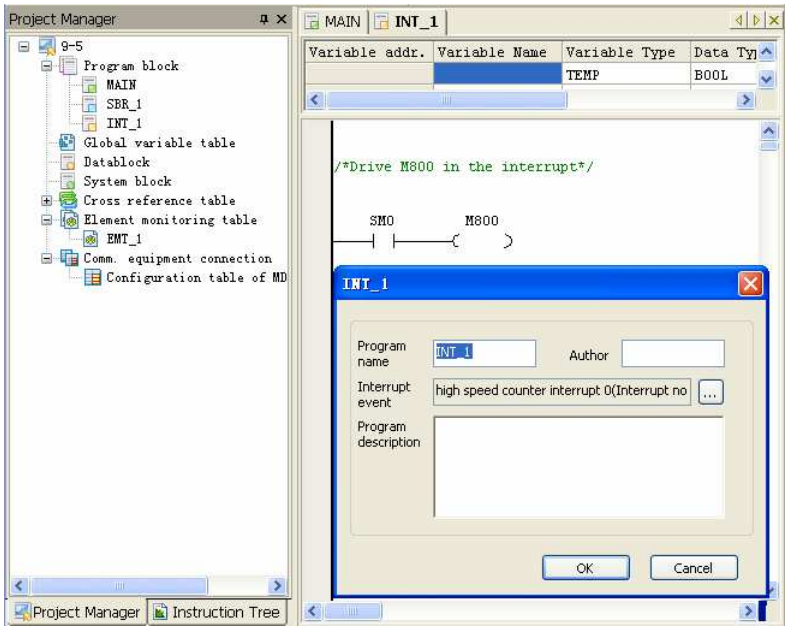
Description

The high-speed counter interrupt must be used together with the HCNT instruction or DHSCI instruction, and generates high-speed counter interrupt based on the value of the high-speed counter. You can compile programs related to external pulse input in the high-speed interrupt program. The high-speed counter interrupts (20 ~ 25) are valid only when the EI instruction and corresponding interrupt enable flag are valid.

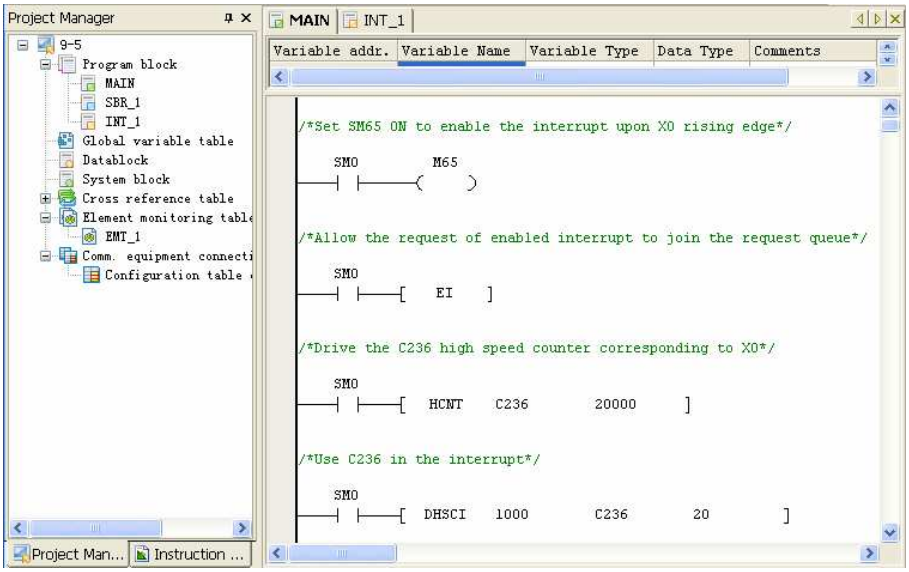
Example

This example uses the high speed counter function of X0 to call the interrupt program (number 20) when the external counter C236 reaches the value specified through the DHSCI instruction.

1. Compile interrupt program, choose an interrupt number for each interrupt subprogram. See the following figure for the specific operation.



2. Write EI instruction in the main program, and set SM65, the interrupt enabling flag of high speed counter interrupt, valid. Drive the high-speed counter C236 and high-speed counter interrupt instruction.



9.6 PTO Output Completion Interrupt

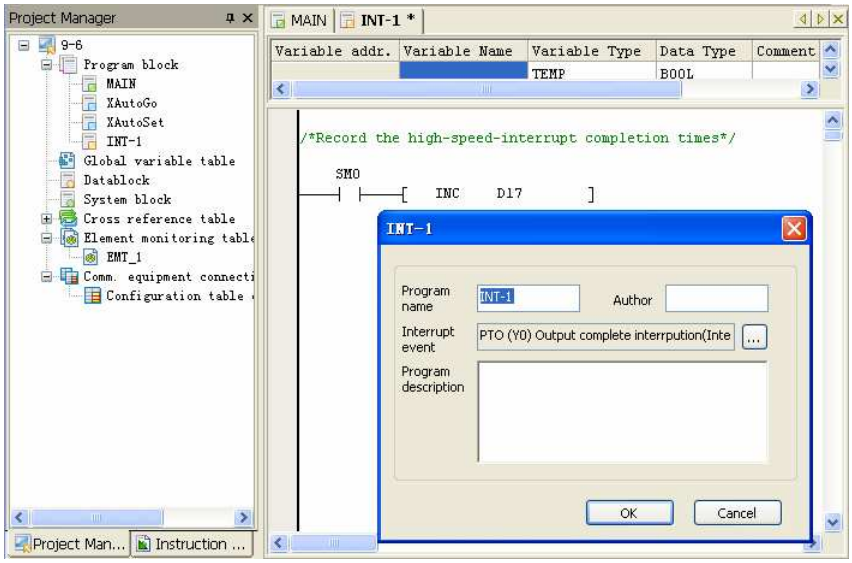
Description

The PTO output completion interrupt is triggered when enable flag (SM63 or SM64) is set and the high-speed pulse output at Y0 or Y1 is finished. You can carry out the relevant processing in the interrupt sub-program. This function is applicable only to IVC1 series PLC.

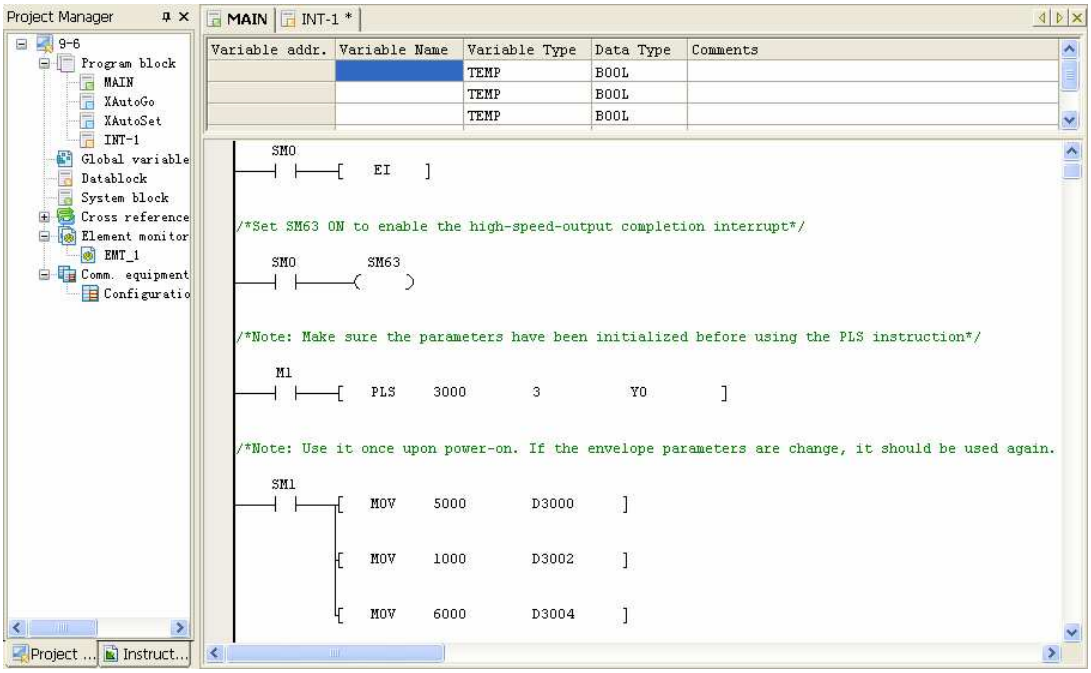
Example

This example uses the high-speed pulse output of Y0 to call the interrupt program (number 18) after Y0 high-speed pulse output is finished.

1. Code function in interrupt program (INT_1): Compile program for the interrupt code to realize the control. Choose the corresponding interrupt number for each interrupt. See INT_1 for the specific operation.



2. Code function in main program: Enable the global interrupt of the system and the enable flag SM63 of PTO output interrupt. Use PLS instruction.



9.7 Power Failure Interrupt

When the enable flag of SM56 is set and the main module has detected the power failure, the power failure interrupt will be triggered and the user can carry out the relevant processing in the interrupt sub-program. This function is applicable only to IVC1 series PLC.

As the power failure interrupt subprogram is executed when the system has no external power supply, the execution duration of power failure interrupt subprogram shall not be over 5ms. Otherwise, the power failure retention component cannot be completely saved.

9.8 Serial Port Interrupt

Description

Serial port interrupt: Under the free port protocol mode of serial port, the system will generate interrupt event based on the sending or receiving events of serial port.

For each serial port, the system supports 4 interrupt resources for the user. The interrupt program of serial port is mainly used when special processing is required for the receiving and sending of character/frame at the serial port and timely processing is requested. It is able to respond to the processing of completing character/frame XMT/RCV without being influenced by scanning time.

Set the ON/OFF status of SM component and the serial port interrupt can be enabled or disabled. When the serial port interrupt is disabled, the ones that have been added to the interrupt queue will continue to be executed.

Do not call the XMT instruction of serial port in the processing subprogram of character sending interrupt when the power flow is normally on. Otherwise, it may lead to interrupt subprogram nesting which blocks the execution of user program.

Interrupt of frame receiving and sending refers to the interrupt event that is delivered after the XMT and RCV instructions of the serial port are executed.

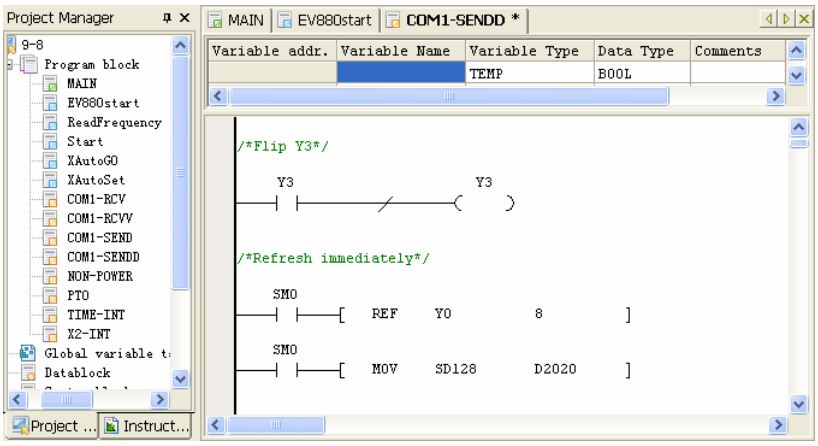
Serial port interrupt resource list:

Event number	Corresponding interrupt event	Interrupt enabling SM
30	Character sending interrupt of communication port 0	SM48
31	Character receiving interrupt of communication port 0	SM49
32	Frame sending interrupt of communication port 0	SM50
33	Frame receiving interrupt of communication port 0	SM51
34	Character sending interrupt of communication port 1	SM52
35	Character receiving interrupt of communication port 1	SM53
36	Frame sending interrupt of communication port 1	SM54
37	Frame receiving interrupt of communication port 1	SM55

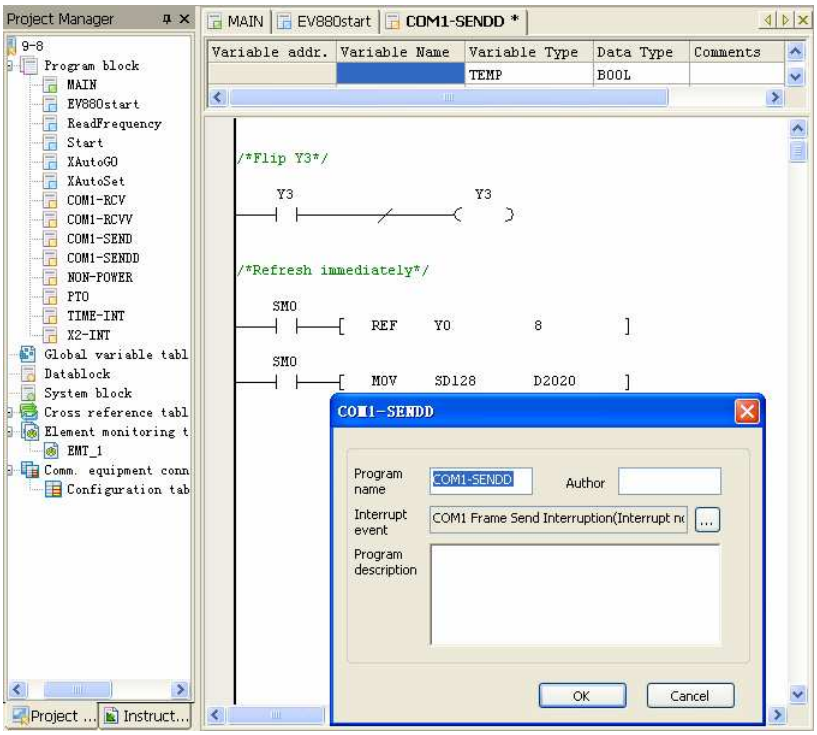
Example

In the example, with the sending interrupt function of serial port frame, the system will flip Y3 output once when a frame is sent out and generate flashing effect based on the frequency of the character sending frame.

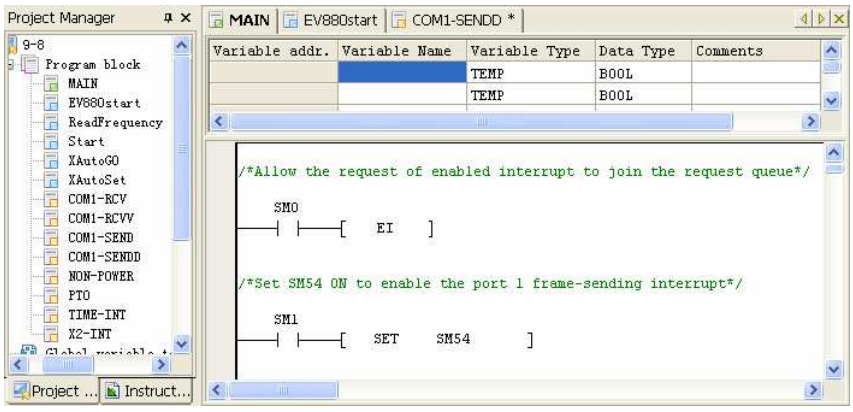
1. Compile interrupt program and the processing code when the serial port sending frame is completed and the interrupt is triggered.



2. Specify interrupt event number for the interrupt program:



3. Compile the code of the sending frame interrupt of enable serial port in the main program.



For the detailed example of serial port interrupt, please refer to *Chapter 10 Using Communication Function*.

Chapter 10 Using Communication Function

This chapter introduces the communication function of IVC series small PLC, including the communication resources and communication protocols, and uses examples to illustrate.

10.1 Communication Resource 245
10.2 Programming Port Protocol 245
10.3 Free Port Communication Protocol 245
10.3.1 Introduction 245
10.3.2 Parameter Setting of Free Port 245
10.3.3 Free Port Instruction 246
10.4 Modbus Communication Protocol 248
10.4.1 Introduction 248
10.4.2 Characteristics Of Links 248
10.4.3 RTU Transfer Mode 248
10.4.4 ASCII Transfer Mode 248
10.4.5 Supported Modbus Function Code 248
10.4.6 Addressing Mode Of PLC Element 249
10.4.7 Modbus Slave 249
10.4.8 Reading & Writing Elements 250
10.4.9 Handle Of Double Word 250
10.4.10 Handle Of LONG INT 251
10.4.11 Diagnostic Function Code 251
10.4.12 Error Code 251
10.4.13 Modbus Parameter Setting 252
10.4.14 Modbus Instruction 252
10.5 N:N bus Communication Protocol 255
10.5.1 Introduction 255
10.5.2 N:N bus Network Structure 256
10.5.3 N:N bus Refresh Mode 256
10.5.4 N:N bus Parameter Setting 261
10.5.5 Example 262

10.1 Communication Resource

The baud rates applicable to IVC series small PLC are listed in the following table:

Communication port	Supported baud rates for different protocols
Communication port 0	115200, 57600, 38400, 19200, 9600, 4800, 2400, 1200
Communication port 1	115200, 57600, 38400, 19200, 9600, 4800, 2400, 1200

The communication protocols that IVC series small PLC supports are listed in the following table:

Basic module	Communication port	Port type	Supported protocol
IVC2	Port 0	RS-232	Programming port protocol, free port protocol, Modbus communication protocol(slave station), N:N bus communication protocol(master station, slave station)
	Port 1	RS-232 or RS-485	Free port protocol, Modbus communication protocol (master station, slave station), N:N bus communication protocol (master station, slave station)
IVC1	Port 0	RS-232	Programming port protocol, free port protocol, Modbus communication protocol (slave station), N:N bus communication protocol (master station, slave station)
	Port 1	RS-232 or RS-485	Free port protocol, Modbus communication protocol (master station, slave station) N:N bus communication protocol (master station, slave station)

You can also set the mode selection switch of IVC series PLC to TM to to transfer port 0 to programming port protocol.

10.2 Programming Port Protocol

The programming port protocol is an internal protocol dedicated to the communication between the host and the PLC.

10.3 Free Port Communication Protocol

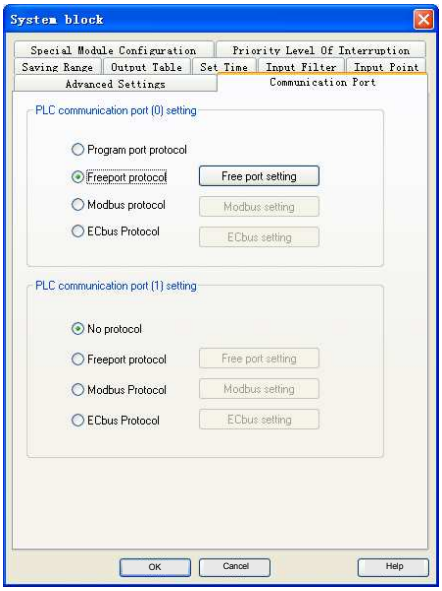
10.3.1 Introduction

The free port protocol is a communication mode with user-defined data file format. It supports two data formats: ASCII and binary. The free port protocol realizes data communication through instructions and can only be used when PLC is in the RUN state.

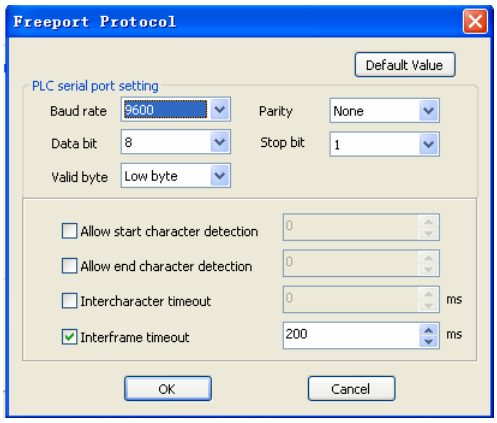
The free port communication instructions include XMT (sending instruction) and RCV (receive instruction).

10.3.2 Parameter Setting of Free Port

Select **Communication Port** in the **System block** dialogue box, and select **Freeport protocol** in port 0 or port 1 setting area to enable the **Freeport setting** button as follows:



The parameter setting of free port is as follows:



Configurable items are listed in the following table:

Item	Setting	Remark
Baud rate	38400,19200, 9600, 4800, 2400, 1200. Defaut: 9600	-
Data bit	7 or 8 (default)	-
Parity	None (default), odd, even	-
Stop bit	1 (default) or 2	-
Allow start character detection	Check to allow. Default: not allowed	-
Start character detection (setting)	0 to 255 (corresponding to 00 to FF)	Start receiving after the designated start character is detected. Save the received characters (including the start character) to the designated BFM
Allow end character detection	Check to allow. Default: not allowed	
End character detection (setting)	0 to 255 (corresponding to 00 to FF)	Stop receiving after the preset end character is received, and save the end character to the BFM
Intercharacter timeout (enabling)	Check to enable. Default: disabled	
Intercharacter timeout (setting)	0 to 65535ms	Stop receiving if the interval between two received characters is longer than the timeout setting
Interframe timeout (enabling)	Check to enabling. Default: disabled	When the power flow is valid and the communication conditions are met, that is, the timing for the receiving is started when the communication serial port has not been taken up, if the receiving of one frame has not been finished when the time is up, terminate the RCV.
Interframe timeout (setting)	0 to 65535 ms	When the RCV power flow is valid and the communication conditions are met, the timing will start as soon as the communication serial port starts to receive. If a frame is not received completely when the set time is up, the reception ends

10.3.3 Free Port Instruction

Points to note

The free port instructions XMT and RCV can be used to send/receive data to/from the designated communication port. For the usage of the free port instruction, refer to *6.12.11 XMT: Free-Port Sending (XMT) Instruction* and *6.12.12 RCV: Free-Port Receiving (RCV) Instruction.*

Note that to use free port instruction on a certain port, you need to set the free port protocol and communication parameter for the communication port through the system block of AutoStation. In addition, you need to download the system setting to the PLC and restart it.

Example

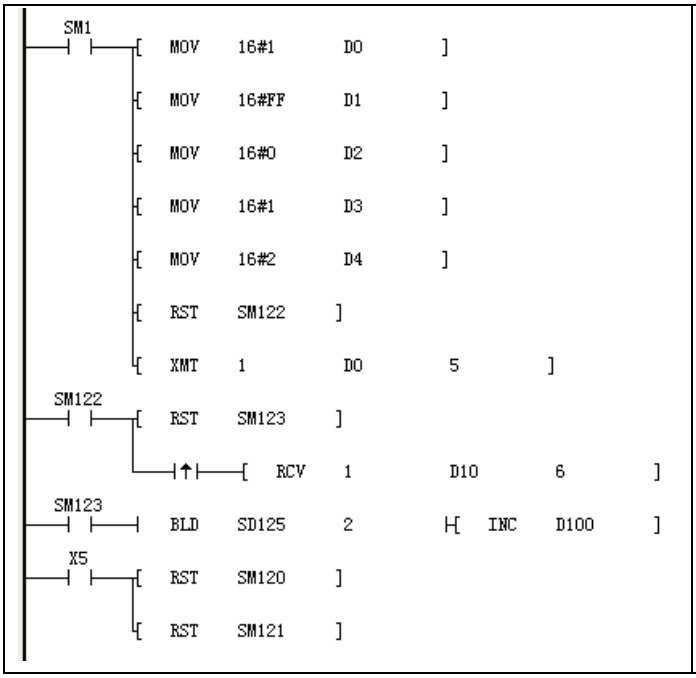
Example 1: Send a 5-byte data and then receive a 6-byte data through communication port 1.

The data to be sent:	01	FF	00	01	02

The data to be received:	01	FF	02	03	05	FE

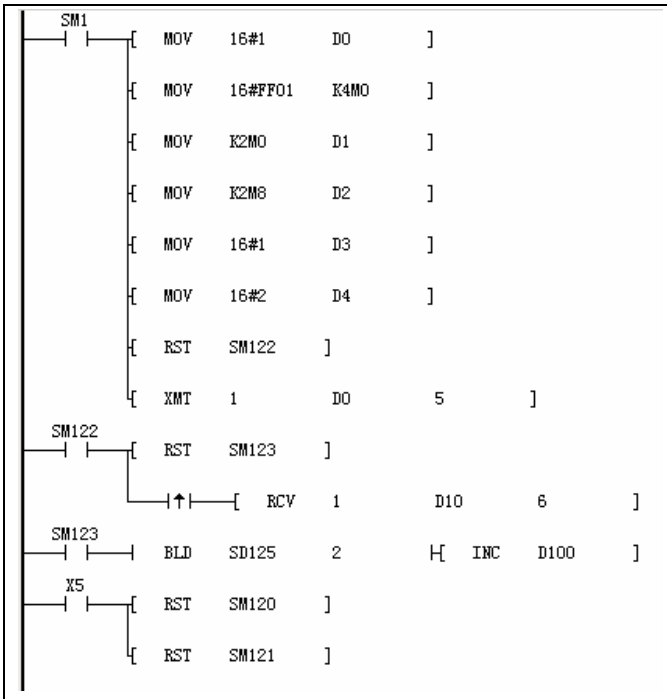
Save the received data to D elements starting with D10. Each byte occupies one D element, as shown below:

01	FF	02	03	05	FE
D10	D11	D12	D13	D14	D15



1. Change the setting of communication port in the system block to free port communication and set the related parameters.
2. When the power flow of SM1 is valid, save the to-be-sent data to the communication BFM starting with D0. Send data with XMT instruction and reset SM122 (transmission complete flag bit) before the sending.
3. Set SM122 after the transmission, and begin to receive data upon the rising edge. The maximum length for the received characters is 6.
4. Set SM123 after the data is received, and perform the corresponding operation based on the receiving completion information register (SD125).
5. Use X5 as the enable bit for interrupting the sending and receiving.

Example 2: Send and receive data through communication port 1.



Different from “Example 1”, when sending the high & low bytes of a word element, the element must be divided into high-& low-byte parts.
For instance, if you want to send the content of D2, you can store its high byte and low byte separately in D3 and D4, and then send D3 and D4. You can also store the data in a K4MX (such as K4M0 of in this example) element. Take K2M0 as high byte and K2M8 as low byte.

10.4 Modbus Communication Protocol

10.4.1 Introduction

For the serial port communication of IVC series small PLC, Modbus communication protocol is available. Two communication modes: ASCII and RTU (IVC1 only supports RTU mode) are supported. The PLC can be set as the master or slave station.

10.4.2 Characteristics Of Links

1. Physical layer: RS-232, RS-485
2. Link layer: asynchronous transfer mode
   1) Data bit: 7 bits (ASCII) or 8 bits (RTU)
   2) Transfer rate: 1200, 2400, 4800, 9600, 19200, 38400
   3) Check method: even check, odd check or no check
   4) Stop bit: 1 or 2 stop bits
3. Networking configuration: up to 31 sets of equipment. Address range: 1 to 31. Broadcast is supported.

10.4.3 RTU Transfer Mode

1. Hexadecimal data.
2. The interval between two characters shall not be less than the time of 1.5 characters.
3. There is no frame head or tail, and the interval between two frames is at least the time of 3.5 characters.
4. Use CRC16 check.
5. The maximum length of RTU frame is 256 bytes and the frame structure is as follows:

Structure of frame	Address	Function code	Data	CRC
Nubmer of Bytes	1	1	0 to 252	2

6. Calculation of interval among characters:

If the communication baud rate is 19200, the interval of 1.5 characters is 1/19200×11×1.5×1000 = 0.86ms.

The interval of 3.5 characters is 1/19200×11×3.5×1000 = 2ms.

10.4.4 ASCII Transfer Mode

1. Use ASCII data communication.
2. The frame takes ": (3A)"as the head, and CRLF (0D 0A) as the tail.
3. The allowed interval among characters is 1s.
4. Use LRC check.
5. The frame of ASCII is longer than that of RTU. It is required two character codes for transferring one byte (HEX) in ASCII mode. The maximum length for data field (2×252) of ASCII is twice of RTU data field (252). The maximum length of ASCII frame is 513 characters and the structure of frame is as follows:

Structure of frame	head	Address	Function code	Data	LRC	Tail
Byte	1	2	2	0 to 2*252	2	2

10.4.5 Supported Modbus Function Code

Supported modbus function codes include 01, 02, 03, 05, 06, 08, 15 and 16.

10.4.6 Addressing Mode Of PLC Element

1. Relationship between read-write element function code and the element:

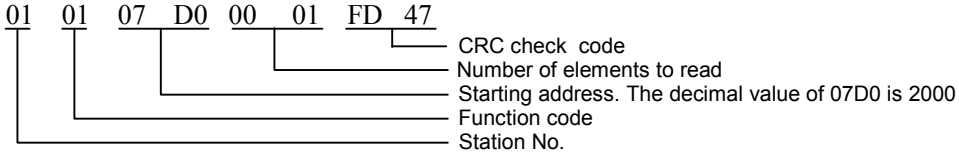
Function code	Name of function code	Modicon data address	Type of operational element	Remark
01	read coil status	0[Note 1]:xxxx	Y, X, M, SM, S, T, C	Bit read
02	read discrete input status	1 [Note 2]:xxxx	X	Bit read
03	read register status	4 [Note 3]:xxxx [Note 4]	D, SD, Z, T, C	Word read
05	write single coil status	0:xxxx	Y, M, SM, S, T, C	Word write
06	write single register status	4:xxxx	D, SD, Z, T, C	Word write
15	write multiple coils status	0:xxxx	Y, M, SM, S, T, C	Bit write
16	write multiple registers status	4:xxxx	D, SD, Z, T, C	Word write

Note:
1. 0 means “coil”.
2. 1 means “discrete input”.
3. 4 means “register”.
4. xxxx means range “1 ~ 9999”. Each type has an independent logic address range of 1 to 9999 (protocol address starts from 0).
5. 0, 1 and 4 do not have the physical meaning and are not involved in actual addressing.
6. Users shall not write X element with function codes 05 and 15; otherwise, the system will not feed back the error information if the written operand and data are correct, but the system will not perform any operation on the write instruction.

2. Relationship between PLC Element and Modbus Communication Protocol Address:

Element	Type	Physical element	Protocol address	Supported function code	Notes
Y	Bit	Y0 ~ Y377 (octal code) 256 points in total	0000 ~ 0255	01, 05, 15	Output status, element code: Y0 toY7, Y10 toY17
X	Bit	X0 ~ X377 (octal code) 256 points in total	1200 to01455 0000 to0255	01, 05, 15 02	Input status, it supports two kinds of address, the element code is same as above
M	Bit	M0 ~ M1999	2000 ~ 3999	01, 05, 15	
SM	Bit	SM0 ~ SM255	4400 ~ 4655	01, 05, 15	
S	Bit	S0 ~ S991	6000 ~ 6991	01, 05, 15	
T	Bit	T0 ~ T255	8000 ~ 8255	01, 05, 15	Status of T element
C	Bit	C0 ~ C255	9200 ~ 9455	01, 05, 15	Status of C element
D	Word	D0 ~ D7999	0000 ~ 7999	03, 06, 16	
SD	Word	SD0 ~ SD255	8000 ~ 8255	03, 06, 16	
Z	Word	Z0 ~ Z15	8500 ~ 8515	03, 06, 16	
T	Word	T0 ~ T255	9000 ~ 9255	03, 06, 16	current value of T element
C	Word	C0 ~ C199	9500 ~ 9699	03, 06, 16	current value of C element (WORD)
C	Double word	C200 ~ C255	9700 ~ 9811	03, 16	current value of C element (WORD)

Note:
The protocol address is the address used on data transfer and corresponds with the logic address of Modicon data. The protocol address starts from 0 and the logic address of Modicon data begins with 1, that is, protocol address + 1 = logic address of Modicon data. For example, if M0 protocol address is 2000, and its corresponding logic address of Modicon data will be 0:2001. In practice, the read and write of M0 is completed through the protocol address, e.g.: read M0 element frame (sent from the master station):


01 01 07 D0 00 01 FD 47
CRC check code
Number of elements to read
Starting address. The decimal value of 07D0 is 2000
Function code
Station No.

10.4.7 Modbus Slave

Modbus slave responds to the master station according to the received message of local address, rather than sending out message actively. The slave only supports Modbus function codes 01, 02, 03, 05, 06, 08, 15 and 16. The other codes are illegal function codes (except broadcast frame).

10.4.8 Reading & Writing Elements

All the function codes supported by IVC2, except 08 are used for read and write of the element. In principle, in one frame, there are 2000 bits and 125 words for reading, 1968 bits and 120 words for writing at most. However, the actual protocol addresses for elements of different types are different and discontinuous (e.g.: Y377's protocol address is 255, X0's protocol address is 1200). Therefore, when reading or writing an element, the element read for one time can only be the same type, and the maximum number of the read elements depends on the elements of this type that are actually defined. For example, when reading element Y (Y0 – Y377, 256 points in total), the protocol address ranges from 0 to 255, the corresponding logic address of Modicon data is from 1 to 256, and the maximum number of elements Y that can be read is 256.

The examples are as follows:

1. XMT from master station: 01 01 00 00 01 00 3D 9A

   01 – address; 01- function code; 00 00 – starting address; 01 00 – number of elements to read; 3D 9A – check

   Response of slave station: provide correct response

2. XMT from master station: 01 01 00 00 01 01 FC 5A

   The starting address for the reading of master station is 0000. 01 01 (257) elements are read, which is beyond the defined number of elements Y.

   Response of slave station: 01 81 03 00 51

   The data from the slave station response is illegal, because 257>256, and 256 is the allowed maximum number of elements Y.

3. XMT from master station: 01 01 00 64 00 A0 7D AD

   The starting address for the reading of master station: 0064 (decimal 100)

   Number of elements read: 00 A0 (decimal 160)

   Slave station response: 01 81 02 C1 91

   The slave station responds with illegal data address, because there are only 156 elements Y starting with the protocol address 100, but 160>156, 160 is illegal.

4. XMT from master station: 01 04 00 02 00 0A D1 CD

   The frame of XMT function code 04 of master station

   Response of slave station: 01 84 01 82 C0

   The slave station responds with illegal function code. 04 is not supported by IVC2.

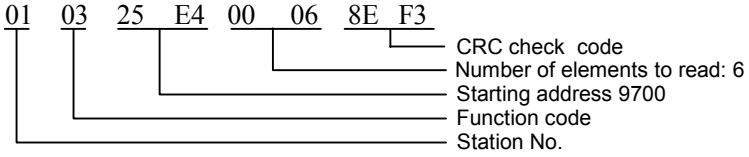
Note

1. Element X does not support write operation (that is, the write of element X is invalid). For the writable properties of elements SM and SD, refer to *Appendix 1 Special Auxiliary Relay* and *Appendix 2 Special Data Register* (if the element is un-writable, the write operation is invalid).
2. The address of the slave station is 01, the last two bytes are CRC check code and the second byte is function code.

10.4.9 Handle Of Double Word

The current count value of C element is word or double word. The value from C200 to C255 are double words, which are read and written through the function code (03, 16) of the register. Every two registers correspond to a C double word. Only the pair can be read and written from/into register upon reading or writing.

For example, read the RTU frame of three C double word elements from C200 to C202:



In the returned data, 9700 and 9701 are two addresses for the content of C200. 9700 is the high 16 bits and 9701 is the low 16 bits.

When reading the double word, if the starting address read is not even number, then the system will respond with error code of illegal address; if the read number of registers is not an even number, the system will respond with error code of illegal data.

For example:

XTM from master station: 01 03 25 E5 00 04 5E F2

The starting address for the reading of master station : 4 word elements of 25 E5 (decimal 9701,)

Response of slave station: 01 83 02 C0 F1

Response of slave station: illegal data address

XTM from slave station: 01 03 25 E4 00 05 CE F2

The starting address for master station read: 5 word elements of 25 E5

Response of slave station: 01 83 03 01 31

The data sent back from slave station is illegal.

10.4.10 Handle Of LONG INT

A LONG INT data can be saved in two D elements. For example, if a LONG INT data is saved in D3 and D4 of IVC series PLC, the high 16 bits will be stored in D3 and the low 16 bits will be stored in D4. This is also true when the master station reads LONG INT data through Modbus and reorganize the data into 32 bits.

The storage principle for FLOAT is the same as the storage principle for LONG INT data.

10.4.11 Diagnostic Function Code

Diagnostic function code is used for test the communication between the master station and slave station, or the internal error of the slave station. The supported diagnostic sub-function codes are as follows:

Function code	Sub-function code	Name of sub-function code		Function code	Sub-function code	Name of sub-function code
08	00	Return query data		08	12	Return bus communication error count
08	01	Restart communication option		08	13	Return bus exceptional error count
08	04	Forced listen only mode		08	14	Return slave message count
08	10	Clear the counter		08	15	Return salve no response count
08	11	Return bus message count		08	18	Return bus character overrun count

10.4.12 Error Code

For the XMT of master station, the slave station returns data or statistic value in the data field under the normal response status. But in the abnormal response status, the server will return error code in the data field. Refer to the following table for error codes:

Error code	Meaning of error code
0x01	illegal function code
0x02	illegal register address
0x03	illegal data

In addition, if the slave station receives data under the following situations, no message will be returned:

1) Error in broadcast frame, e.g. data error, address error;

2) Characters overrun, e.g. RTU frame over 256 bytes;

3) Under RTU transfer mode, interval between two characters time out, which is the same as receiving error frame, and no message will be returned;

4) Listen-only mode of slave station;

5) The slave station received ASCII error frame, including frame tail error, character range error.

Note

Read station is equipped with compulsory element. What is read is the value run by the program, which may be inconsistent with the compulsory value.

10.4.13 Modbus Parameter Setting

Set communication port in system block

There are two serial ports (serial port 0 and 1) on the communication port interface. Communication port 0 only supports Modbus slave station, while communication port 1 supports both master and slave stations.

Set Modbus communication parameters

There is a button of default value on Modbus operand interface. The default value is the communication setting recommended by Modbus communication protocol. For the parameter setting items, refer to Table XX.

Item	Setting
Station No.	0 to 31
Baud rate	38400, 19200, 9600, 4800, 2400, 1200
Data bit	set to 7 or 8 bits; 7 for ASCII mode, 8 for RTU mode
Parity check bit	set to no check, odd check and even check
Stop bit	set to 1 or 2; set to 1 for odd or even check; set to 2 for no check status
Modbus master/slave	It can be set to master or slave station; communication port 1 can be set to master/slave station, communiation port 0 can only be set to slave station
transfer mode	Select RTU mode or ASCII mode
main mode timeout	The time for waiting the slave response by master is over the set value.
Note: After the operand is set and downloaded in the system block, it will be valid only after one operation.	

10.4.14 Modbus Instruction

When PLC is used as Modbus master station, the Modbus data frame can be sent/received through Modbus instruction provided by system. For the detailed use of Modbus instruction, refer to *6.12.1 Modbus: Modbus Master Station Communication Instruction*.

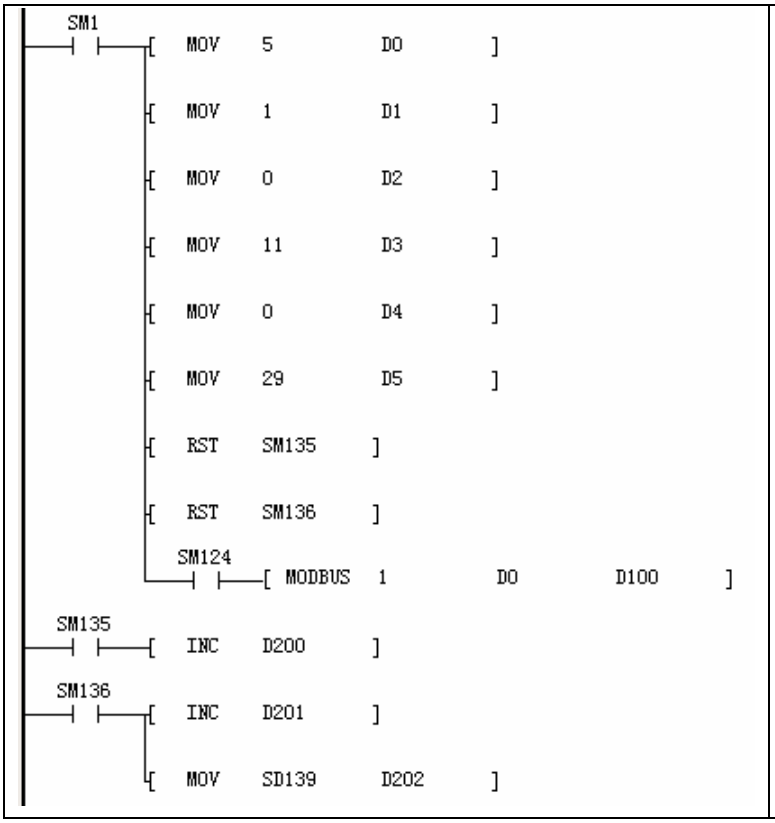
If PLC is set to master station, there is a timeout item in main mode when setting Modbus parameter in the system block. To ensure the correctness of the received data, the timeout period shall be longer than a scan cycle of Modbus slave station and with reasonable margin. For example, if IVC2 is the slave station and a scan cycle of IVC2 is 300ms, the main mode timeout of the master station shall be over 300ms. It is proper to set the timeout to 350ms.

Application program

Example 1: When IVC2 PLC is Modbus master station as well as slave station, read bit status of No.5 station. The protocol address of slave station read by master station is the bit value ranging from 11 to 39. Assuming that the read data are as follows, the storage location for the received data starts from D100, save the address to D100, function code to D101 and number of registers in D102. Save the read bit value in the units beginning with D103.

42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
X	X	X	0	0	1	1	0	0	0	0	1	0	1	1	0
D106								D105							
26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11
1	1	0	0	0	1	1	0	1	1	1	0	0	0	0	1
D104								D103							

If the read number of the registers is not the times of 8, add 0 to the high bits. In the above example, it has added 0 to 3 high bits (40, 41 and 42) in D106.



1. Designate 5 as the address of the slave station to be accessed (save to D0).
2. Designate 1 as the function code (save to D1).
3. The address of the register to be read is 11 (Save to D2/D3 according to high and low bytes).
4. The number of registers to be read is 29 (Save to D4/D5 according to high bits and low bits).
5. The received data is saved to D100.
6. If the receive is completed (set SM135), add 1 to D200.
7. If the communication fails (set SM136), add 1 to D201 and save the error code to D202.
8. SM124 is the idle flag of the communication port.

Note

1. When logic address is used for addressing the bit element of IVC2 PLC, the logic address 1 is the protocol address 0. In the above example, reading the value of 11 ~ 39 bits (protocol address) in the slave station, the logic address shall start from 12.

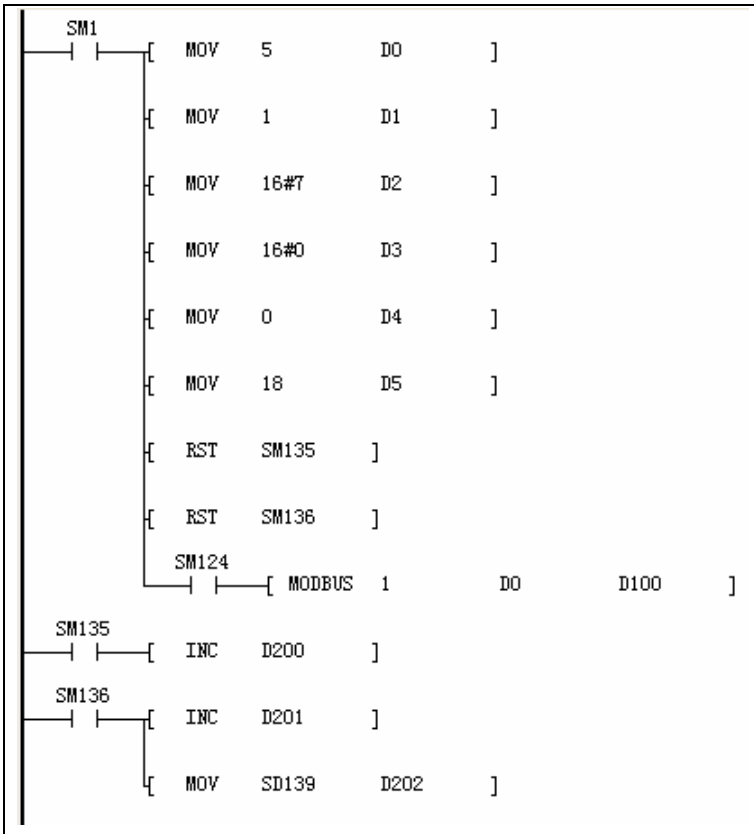
2. The failure of this communication will not affect the next communication, that is, if there are two Modbus XMT instructions in one user program, the first communication fails and has error code, it will not influence the data sending of the second Modbus instruction. Thus, in the example, we placed the error code of SD139 in D202, which can be observed through D202.

3. For the message sending of the slave station, if the master station is in listen-only mode, there will be no data to be returned and the system will display error flag. Therefore, when using Modbus of IVC2, if IVC2 is the master station, the user shall clearly know which PLC slave station is under listen-only mode, so as to ensure that the failure of the communication is not caused by the listen-only mode of the slave station.

Example 2: IVC2 is the Modbus master station, the slave station is also an IVC2 basic module. Read the status of bit elements (protocol address: 2000 ~ 2017) in No.5 station.

The read data are as follows:

- The received frame starts from D100.
- D100 is for saving address
- D101 is for saving function code
- D102 is for saving the number of registers
- Units beginning with D103 are for saving the read value of bit element



1. The program has designated 5 as the address of the slave station to be accessed (save to D0).
2. The program has designated 1 as function code (save to D1).
3. The starting address of the register to be read is 07D0 (hexadecimal, save to D2/D3 according to high bits and low bits).
4. The number of registers to be read is 18 (Save to D4/D5 according to high bits and low bits).
5. The received data is saved to D100.
6. If the receive is completed (set SM135), add 1 to D200.
7. If the communication fails (set SM136), add 1 to D201 and save the error code to D202.
8. SM124 is the idle flag of the communication port.

Example 3: IVC2 is the Modbus master station as well as the slave station. Read the status of the bit element with the protocol address ranging from 40 to 43 of No.5 station.

The read data are as follows:

The received frame starts from D100.

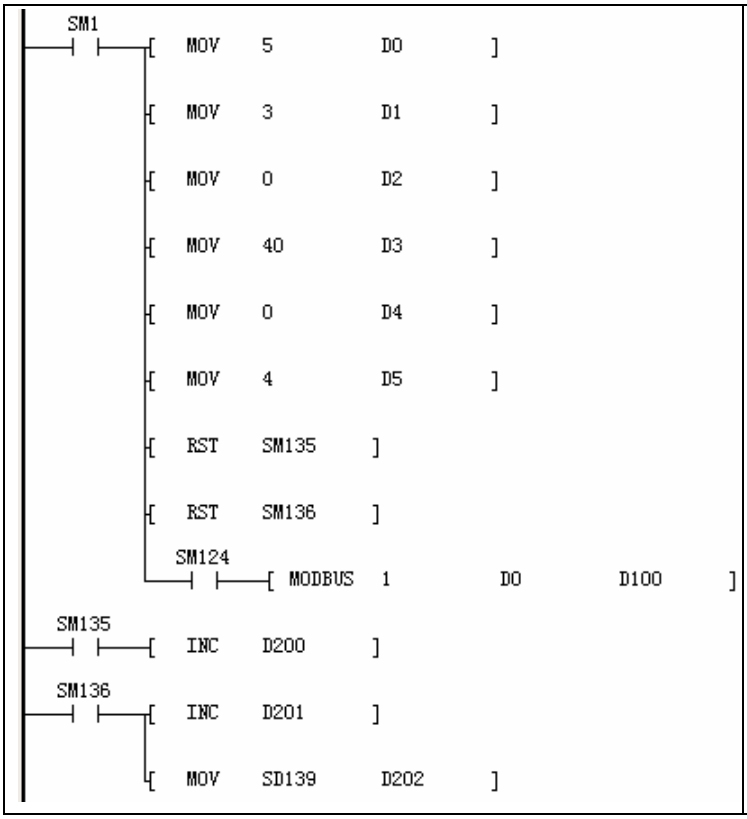
D100 is for saving address

D101 is for saving function code

D102 is for saving the number of registers

Units beginning with D103 are for saving the read value of bit element

40 element high bits	40 element low bits	41 element high bits	41 element low bits	42 element high bits	42 element low bits	43 element high bits	43 element LSB
D103	D104	D105	D106	D107	D108	D109	D110



1. The program has designated 5 as the address of the slave station to be accessed (save to D0).
2. The program has designated 3 as function code (save to D1).
3. The starting address of the register to be read is 40 (save to D2/D3 according to high bits and low bits).
4. The number of registers to be read is 4 (Save to D4/D5 according to high bits and low bits).
5. The received data is saved to D100.
6. If the receiving is completed (set SM135), add 1 to D200.
7. If the communication fails (set SM136), add 1 to D201 and save the error code to D202.
8. SM124 is the idle flag of the communication port.

10.5 N:N bus Communication Protocol

10.5.1 Introduction

N:N bus is a small PLC network developed by Invt Auto-Control Technology Co., Ltd. The physical layer of N:N bus uses RS-485, so the PLC can be directly connected through communication port 1 or connected through communication port 0 by RS-232/RS-485 converter. The connected PLC of N:N bus can automatically exchange the values between D elements and M elements , which makes the access to the other PLC elements on the network as convenient as accessing its own element. In N:N bus, the data access between PLCs is completely equivalent (N:N communication network).

It is convenient to configure N:N bus. Most parameters of N:N bus only need to be configured on No.0 PLC. In addition, N:N bus supports online modification of the network parameters, and is able to detect the newly added PLC automatically. If any PLC is disconnected from the network, the other PLCs will continue to exchange the data. It is also able to monitor the communication status of the whole network through the relevant SM element of any PLC in N:N bus.

10.5.2 N:N bus Network Structure

N:N bus supports two kinds of network: single-layer network and multiple-layer network (as shown in the following figures):

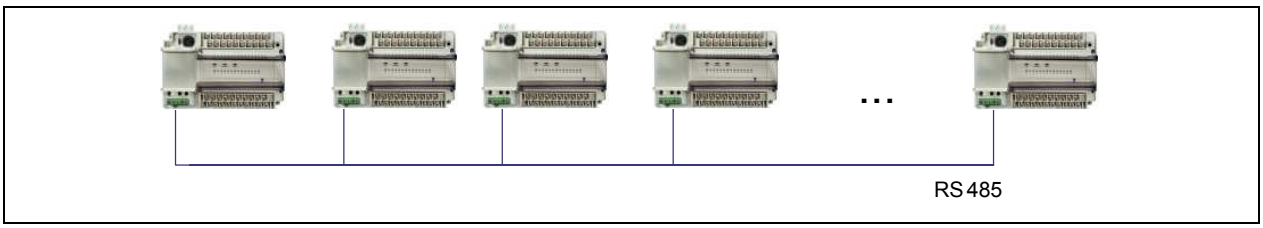


Figure 10-1 N:N bus single-layer network

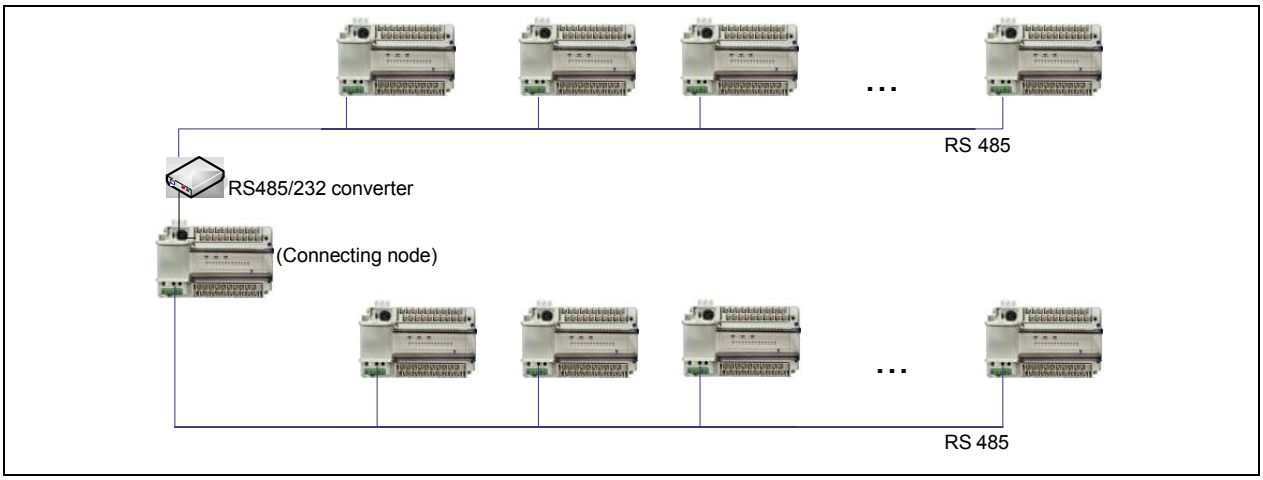
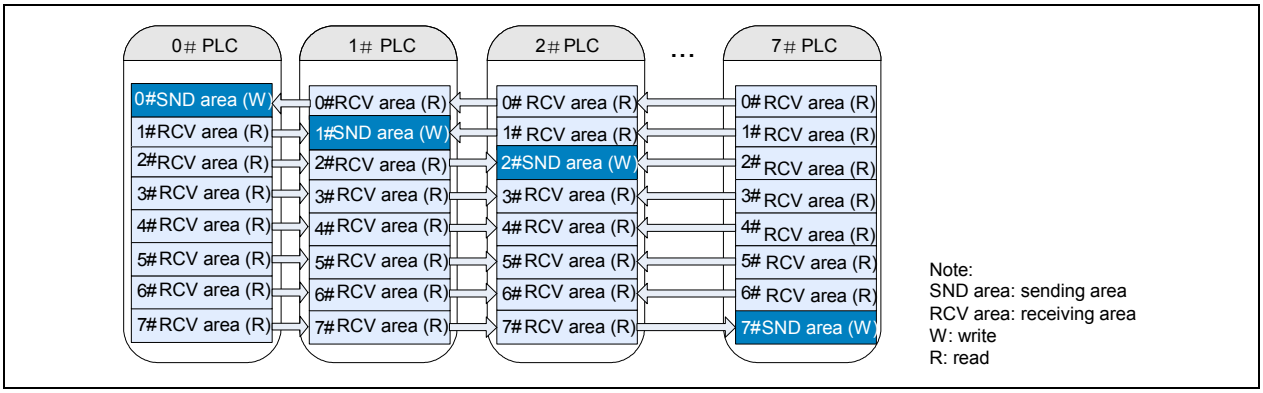


Figure 10-2 N:N bus multiple-layer network

In the single-layer network, each PLC only connects to N:N bus through 1 communication port. In the multiple-layer network, the layer-to-layer PLC (intermediate node) shall be connected, and the two communication ports of PLC shall be connected to different layers. The single-layer network can support up to 32 PLCs , while each layer of multiple-layer network can support 16 PLCs at most.

10.5.3 N:N bus Refresh Mode

The PLCs connected to N:N bus can automatically realize the exchange between parts of D elements and M elements in the network. The quantity and numbering of elements D and M are fixed, and the elements are called “Elements Sharing Area”. If PLC uses N:N bus, the value of the Elements Sharing Area will keep refreshing automatically, so as to keep the value consistency of the Elements Sharing Area for each PLC in the network.



As shown in the above figure, each PLC with N:N bus connected has a writable sending area in the Elements Sharing Area. N:N bus will automatically send the information (values of designated elements D and M) of the writable sending area to other PLCs, receive the information from other PLCs and save it to the read-only sending area.

The element number in the Elements Sharing Area is fixed (64 D elements and 512 M elements can be shared) and these elements are distributed to more than one PLC. Therefore, the less PLCs are connected to the network, the more elements can be distributed to each PLC. The relationship is defined by N:N bus refresh mode:

Distribution of D element on N:N bus single-layer network:

Distribution of D element in sending area	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
D7700 to D7701	#0	#0	#0	#0	#0
D7702 to D7703	#1				
D7704 to D7705	#2	#1			
D7706 to D7707	#3				
D7708 to D7709	#4	#2	#1		
D7710 to D7711	#5				
D7712 to D7713	#6	#3			
D7714 to D7715	#7				
D7716 to D7717	#8	#4	#2	#1	
D7718 to D7719	#9				
D7720 to D7721	#10	#5			
D7722 to D7723	#11				
D7724 to D7725	#12	#6	#3		
D7726 to D7727	#13				
D7728 to D7729	#14	#7			
D7730 to D7731	#15				
D7732 to D7733	#16	#8	#4	#2	#1
D7734 to D7735	#17				
D7736 to D7737	#18	#9			
D7738 to D7739	#19				
D7740 to D7741	#20	#10	#5		
D7742 to D7743	#21				
D7744 to D7745	#22	#11			
D7746 to D7747	#23				
D7748 to D7749	#24	#12	#6	#3	
D7750 to D7751	#25				
D7752 to D7753	#26	#13			
D7754 to D7755	#27				
D7756 to D7757	#28	#14	#7		
D7758 to D7759	#29				
D7760 to D7761	#30	#15			
D7762 to D7763	#31				

Explanation:

1) In mode 1, the D elements distributed to the sending area by 0# station are D7700 and D7701. D7700 and D7701 can be written by the PLC of 0# station, and directly read by other stations (1#--31#).

2) In mode 2, the D elements distributed to the sending area by 0# station are D7700, D7701, D7701 and D7703. The elements can be written by the PLC of 0# station and directly read by other stations (1#--15#).

Distribution of M element on N:N bus single-layer network:

<table>
<tr><th>Distribution of M element in sending area</th><th>Mode 1</th><th>Mode 2</th><th>Mode 3</th><th>Mode 4</th><th>Mode 5</th></tr>
<tr><td>M1400 to M1415</td><td>#0</td><td rowspan="2">#0</td><td rowspan="4">#0</td><td rowspan="8">#0</td><td rowspan="12">#0</td></tr>
<tr><td>M1416 to M1431</td><td>#1</td></tr>
<tr><td>M1432 to M1447</td><td>#2</td><td rowspan="2">#1</td></tr>
<tr><td>M1448 to M1463</td><td>#3</td></tr>
<tr><td>M1464 to M1479</td><td>#4</td><td rowspan="2">#2</td><td rowspan="4">#1</td></tr>
<tr><td>M1480 to M1495</td><td>#5</td></tr>
<tr><td>M1496 to M1511</td><td>#6</td><td rowspan="2">#3</td></tr>
<tr><td>M1512 to M1527</td><td>#7</td></tr>
<tr><td>M1528 to M1543</td><td>#8</td><td rowspan="2">#4</td><td rowspan="4">#2</td><td rowspan="8">#1</td></tr>
<tr><td>M1544 to M1559</td><td>#9</td></tr>
<tr><td>M1560 to M1575</td><td>#10</td><td rowspan="2">#5</td></tr>
<tr><td>M1576 to M1591</td><td>#11</td></tr>
<tr><td>M1592 to M1607</td><td>#12</td><td rowspan="2">#6</td><td rowspan="4">#3</td><td rowspan="4">#0</td></tr>
<tr><td>M1608 to M1623</td><td>#13</td></tr>
<tr><td>M1624 to M1639</td><td>#14</td><td rowspan="2">#7</td></tr>
<tr><td>M1640 to M1655</td><td>#15</td></tr>
<tr><td>M1656 to M1671</td><td>#16</td><td rowspan="2">#8</td><td rowspan="4">#4</td><td rowspan="8">#2</td><td rowspan="16">#1</td></tr>
<tr><td>M1672 to M1687</td><td>#17</td></tr>
<tr><td>M1688 to M1703</td><td>#18</td><td rowspan="2">#9</td></tr>
<tr><td>M1704 to M1719</td><td>#19</td></tr>
<tr><td>M1720 to M1735</td><td>#20</td><td rowspan="2">#10</td><td rowspan="4">#5</td></tr>
<tr><td>M1736 to M1751</td><td>#21</td></tr>
<tr><td>M1752 to M1767</td><td>#22</td><td rowspan="2">#11</td></tr>
<tr><td>M1768 to M1783</td><td>#23</td></tr>
<tr><td>M1784 to M1799</td><td>#24</td><td rowspan="2">#12</td><td rowspan="4">#6</td><td rowspan="8">#3</td></tr>
<tr><td>M1800 to M1815</td><td>#25</td></tr>
<tr><td>M1816 to M1831</td><td>#26</td><td rowspan="2">#13</td></tr>
<tr><td>M1832 to M1847</td><td>#27</td></tr>
<tr><td>M1848 to M1863</td><td>#28</td><td rowspan="2">#14</td><td rowspan="4">#7</td></tr>
<tr><td>M1864 to M1879</td><td>#29</td></tr>
<tr><td>M1880 to M1895</td><td>#30</td><td rowspan="2">#15</td></tr>
<tr><td>M1896 to M1911</td><td>#31</td></tr>
</table>

Explanation:

1) In mode 1, the M elements distributed to the sending area by 0# station range from M1400 to M1415. The elements can be written by the PLC of 0# station and directly read by other stations (1#--31#).

2) In mode 2, the M elements distributed to the sending area by 0# station range from M1400 to M1431. The elements can be written by the PLC of 0# station and directly read by other stations (1#--31#).

Distribution of D element on N:N bus multiple-layer network (layer 0):

Distribution of D element in sending area	Mode 6	Mode 7	Mode 8	Mode 9
D7700 to D7701	#0	#0	#0	#0
D7702 to D7703	#1			
D7704 to D7705	#2	#1		
D7706 to D7707	#3			
D7708 to D7709	#4	#2	#1	
D7710 to D7711	#5			
D7712 to D7713	#6	#3		
D7714 to D7715	#7			
D7716 to D7717	#8	#4	#2	#1
D7718 to D7719	#9			
D7720 to D7721	#10	#5		
D7722 to D7723	#11			
D7724 to D7725	#12	#6	#3	
D7726 to D7727	#13			
D7728 to D7729	#14	#7		
D7730 to D7731	#15			

Explanation:

In mode 6, D7700 and D7701 are distributed to the sending area by 0# station (layer 0). They can be written by the PLC of 0# station and directly read by the other stations (1#--15#).

Distribution of D element on N:N bus multiple-layer network (layer 1):

Distribution of D element in sending area	Mode 10	Mode 11	Mode 12	Mode 13
D7732 to D7733	#0	#0	#0	#0
D7734 to D7735	#1			
D7736 to D7737	#2	#1		
D7738 to D7739	#3			
D7740 to D7741	#4	#2	#1	
D7742 to D7743	#5			
D7744 to D7745	#6	#3		
D7746 to D7747	#7			
D7748 to D7749	#8	#4	#2	#1
D7750 to D7751	#9			
D7752 to D7753	#10	#5		
D7754 to D7755	#11			
D7756 to D7757	#12	#6	#3	
D7758 to D7759	#13			
D7760 to D7761	#14	#7		
D7762 to D7763	#15			

Explanation:

In mode 10, D7732 and D7733 are distributed to the sending area by 0# station (layer 0). They can be written by the PLC of 0# station and directly read by the other stations (1#--15#).

Distribution of M element on N:N bus multiple-layer network (layer 0):

Distribution of M element in sending area	Mode 6	Mode 7	Mode 8	Mode 9
M1400 to M1415	#0	#0	#0	#0
M1416 to M1431	#1			
M1432 to M1447	#2	#1		
M1448 to M1463	#3			
M1464 to M1479	#4	#2	#1	
M1480 to M1495	#5			
M1496 to M1511	#6	#3		
M1512 to M1527	#7			
M1528 to M1543	#8	#4	#2	#1
M1544 to M1559	#9			
M1560 to M1575	#10	#5		
M1576 to M1591	#11			
M1592 to M1607	#12	#6	#3	
M1608 to M1623	#13			
M1624 to M1639	#14	#7		
M1640 to M1655	#15			

Explanation:

In mode 6, the M elements distributed to the sending area by 0# station (layer 0) range from M1400 to M1415. The elements can be written by the PLC of 0# station and directly read by other stations (1#--15#).

Distribution of M element on N:N bus multiple-layer network (layer 1):

Distribution of M element in sending area	Mode 10	Mode 11	Mode 12	Mode 13
M1656 to M1671	#0	#0	#0	#0
M1672 to M1687	#1			
M1688 to M1703	#2	#1		
M1704 to M1719	#3			
M1720 to M1735	#4	#2	#1	
M1736 to M1751	#5			
M1752 to M1767	#6	#3		
M1768 to M1783	#7			
M1784 to M1799	#8	#4	#2	#1
M1800 to M1815	#9			
M1816 to M1831	#10	#5		
M1832 to M1847	#11			
M1848 to M1863	#12	#6	#3	
M1864 to M1879	#13			
M1880 to M1895	#14	#7		
M1896 to M1911	#15			

Explanation:

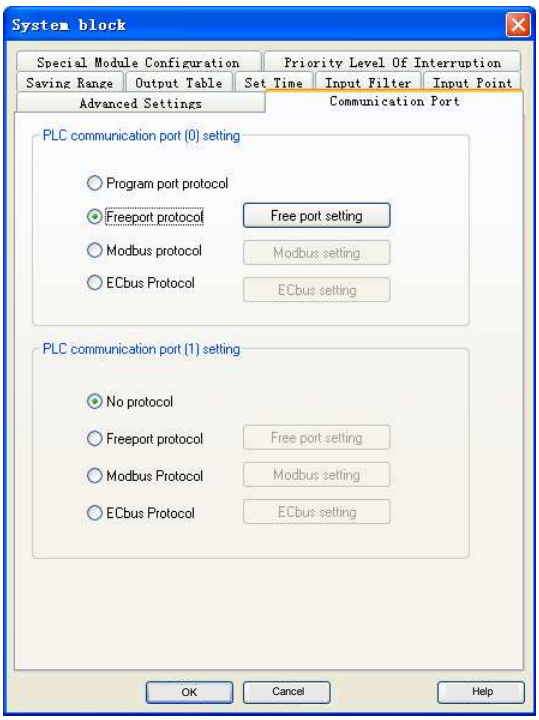
In mode 10, the M elements distributed to the sending area by 0# station (layer 1) range from M1656 to M1671. The elements can be written by the PLC of 0# station and directly read by other stations (1#--15#).

Note:

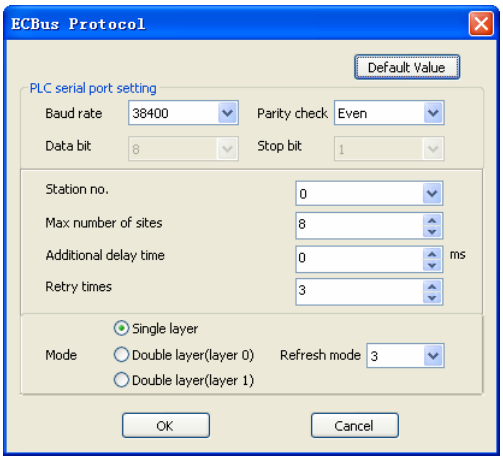
Once PLC is configured with N:N bus communication protocol, D7700 ~ D7763 and M1400 ~ M1911 will become the public resource for data exchange on the network. Please pay attention to these elements when using them in the program!

10.5.4 N:N bus Parameter Setting

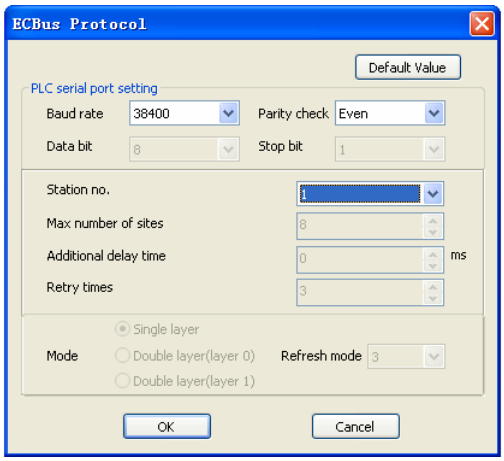
Select **Communication Port** in the **System block** dialogue box, and select **N:N bus protocol** in the port 0 or port 1 setting area to enable the **N:N bus setting** button as follows:



Click the **N:N bus setting** button to enter the **N:N bus protocol** setting dialogue box as shown below:



As shown in the preceding figure, the N:N bus parameters are set through the system block. The **Station no.** shall begin with 0#. Several PLCs cannot share the same station number. 0# station is used for starting and setting the whole network. The setting of **Max number of sites**, **Additional delay time**, **Retry times** and **Mode** can be realized through 0# station. For the stations with other station numbers, except that the **Baud rate** and **Parity check** shall be consistent with those of 0# station, they only need to set their own **Station no.**, as shown in the following figure:



The **Max number of sites** refers to the total number of PLCs used in the network. If 6 PLCs are used in total, the value shall be set to 6 and the station number of the 6 PLCs ranges from 0 to 5. If you want to add another two PLCs to the network later without any interruption of the network, you can set the **Max number of sites** to 8. The numbers of the newly added PLCs are 6# and 7#. When 6# and 7# are connected to the network, they will be automatically detected by N:N bus within one second and included into the data exchange with 0#-5#.

10.5.5 Example

There are 5 PLCs in total and the station numbers range from 0＃ to 4＃. Select 3 for the refresh mode. If you want to save the sum of D100 in 0＃PLC and D305 in 2＃PLC to the D500 of 4＃PLC, you can program as follows:

Programming 0#: **MOV D100 D7700**

Programming 2#: **MOV D305 D7716**

Programming 4#: **ADD D7700 D7716 D500**

Explanation: The example shows the N:N bus single-layer network. There are 5 PLC stations on the network and the refresh mode is set to 3. Each station can be distributed with 8 D elements and 64 M elements. The D elements distributed to 0# station range from D7700 to D7707, the ones to 2# station range from D7716 to D7723 and the ones to 4# station range from D7732 to D7739. Save the D100 value of 0# station to the public area D7700 distributed by the network, D305 value of 2# station to the public area D7716 distributed by the network. Execute sum operation of D7700 and D7716 in 4#PLC and save the sum to the local element D500.

Appendix 1 Special Auxiliary Relay

All the special auxiliary relays are initialized when the PLC changes from STOP to RUN. Those that have been set in system setting will be set to the preset value after that initialization.

🕮 **Note**

The reserved SD and SM elements are not listed in the table. The reserved SM elements are by default read only (R).

1. PLC Work State Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM0	Monitoring run bit	This bit is high in the RUN state, and low in the STOP state	R	√	√
SM1	Initial run pulse bit	This bit is set high when PLC changes form STOP to RUN, and set low after a scan cycle	R	√	√
SM2	Power on flag bit	This bit is set high after system power-on, and set low after a scan cycle	R	√	√
SM3	System error	This bit is set when system error occurs after power-on or after PLC changes from STOP to RUN, or reset if no system error occurs	R	√	√
SM4	Battery voltage low	This bit is set when the battery voltage is too low, or reset if the battery voltage is detected higher than 2.4V	R	√	
SM5	AC power failure detection bit	This bit is set when PLC detects AC power off (detecting time 40ms). If the power is on after the delay of power off detecting time (set in SD05), the bit will be reset	R	√	√
SM6	24Vdc power failure	This bit is set when PLC detects the 24Vdc power failure (detecting time 50ms). If within the following 50ms the power is detected to be back, this bit will be reset	R	√	√
SM7	No battery work mode	If this bit is set as 1 (configurable only through system block), the Battery-backed data lost error (code: 43) and the Forced-table lost error (code: 44) will not be reported upon system battery failure	R	√	
SM8	Constant scan mode	Set this bit, and the scan time will be constant (configurable only through system block)	R	√	√
SM9	Input point startup mode	Set this bit, and the PLC can change from STOP to ON when the designated X input point is ON (configurable only through system block)	R	√	√

2. Clock Running Bit

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM10	10ms clock	Crystal oscillation (period: 10ms). Reverse every half period. The first half period is 0 when the user program starts	R	√	√
SM11	100ms clock	Crystal oscillation (period: 100ms). Reverse every half period. The first half period is 0 when the user program starts	R	√	√
SM12	1s clock	Crystal oscillation (period: 1s). Reverse every half period. The first half period is 0 when the user program starts	R	√	√
SM13	1min clock	Crystal oscillation (period: 1min). Reverse every half period. The first half period is 0 when the user program starts	R	√	√
SM14	1hour clock	Crystal oscillation (period: 1 hour). Reverse every half period. The first half period is 0 when the user program starts	R	√	√
SM15	Scan cycle oscillation bit	This bit reverses once every scan cycle (The first period is 0 when the user program starts)	R	√	√

3. User Program Execution Error

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM20	Instruction execution error	This bit is set upon instruction execution error. Ths corresponding error type code is written into SD20. This bit is cleared after the execution succeeds	R	√	√
SM21	Instruction register number subscript overflow	This bit is set upon instruction execution error. The corresponding error type code is written into SD20	R	√	√
SM22	Instruction parameter illegal	This bit is set upon instruction execution error. The corresponding error type code is written into SD20. This bit is cleared after the execution succeeds	R	√	√

4. Interrupt Control

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM40	X0 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM41	X1 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM42	X2 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM43	X3 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM44	X4 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM45	X5 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM46	X6 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM47	X7 input rising/falling edge interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM48	COM 0 character transmission interrupt enabling flag bit	Enable when set as 1	R/W		√
SM49	COM 0 character reception interrupt enabling flag bit	Enable when set as 1	R/W		√
SM50	COM 0 frame transmission interrupt enabling flag bit	Enable when set as 1	R/W		√
SM51	COM 0 frame reception interrupt enabling flag bit	Enable when set as 1	R/W		√
SM52	COM 1 character transmission interrupt enabling flag bit	Enable when set as 1	R/W		√
SM53	COM 1 character reception interrupt enabling flag bit	Enable when set as 1	R/W		√
SM54	COM 1 frame transmission interrupt enabling flag bit	Enable when set as 1	R/W		√
SM55	COM 1 frame reception interrupt enabling flag bit	Enable when set as 1	R/W		√
SM56	Power failure interrupt	Enable when set as 1	R/W		√
SM63	PTO (Y0) output finish interrupt enable flag bit	Enable when set as 1	R/W		√
SM64	PTO (Y1) output finish interrupt enable flag bit	Enable when set as 1	R/W		√
SM65	High speed counter interrupt enabling flag bit	Enable when set as 1	R/W	√	√
SM66	Timed interrupt 0 enabling flag bit	Enable when set as 1	R/W	√	√
SM67	Timed interrupt 1 enabling flag bit	Enable when set as 1	R/W	√	√
SM68	Timed interrupt 2 enabling flag bit	Enable when set as 1	R/W	√	√

5. High Speed Pulse Output Control

Addr.	Name	Function	R/W	IVC2	IVC1
SM80	Y0 high speed pulse output control	Y0 high speed pulse output stop instruction	R/W	√	√
SM81	Y1 high speed pulse output control	Y1 high speed pulse output stop instruction	R/W	√	√
SM82	Y0 high speed pulse output monitor	Y0 high speed pulse output mointor (ON: busy. OFF: ready)	R	√	√
SM83	Y1 high speed pulse output monitor	Y1 high speed pulse output mointor (ON: busy. OFF: ready)	R	√	√
SM85	Reset function valid	Output of CLR signal for ZRN instruction enabled	R/W		√

6. Pulse Capture Monitoring Bit

Addr.	Name	Function	R/W	IVC2	IVC1
SM90	Input X0 pulse capture monitoring bit	Capture rising edge pulse at input X0	R/W	√	√
SM91	Input X1 pulse capture monitoring bit	Capture rising edge pulse at input X1	R/W	√	√
SM92	Input X2 pulse capture monitoring bit	Capture rising edge pulse at input X2	R/W	√	√
SM93	Input X3 pulse capture monitoring bit	Capture rising edge pulse at input X3	R/W	√	√
SM94	Input X4 pulse capture monitoring bit	Capture rising edge pulse at input X4	R/W	√	√
SM95	Input X5 pulse capture monitoring bit	Capture rising edge pulse at input X5	R/W	√	√
SM96	Input X6 pulse capture monitoring bit	Capture rising edge pulse at input X6	R/W	√	√
SM97	Input X7 pulse capture monitoring bit	Capture rising edge pulse at input X7	R/W	√	√

Note:

1. All the elements in this table are cleared when the PLC changes from STOP to RUN. The pulse capture will fail when the HSNT or SPD instruction is being executed at the same input point. For details, see *6.10.8 SPD:* Pulse Detection Instruction and *6.10.1 HCNT: High-speed Counter Drive Instruction*.
2. For hardware counters, the total pulse frequency input through X0 ~ X7 (using pulse capture, SPD instruction or HCNT instructions, but not high speed compare instructions) is ≤80k. For software counters, that frequency (using instructions DHSCS, DHSCI, DHSZ, DHSP or DHST for driven high speed counters) is ≤30k.

7. Free Port (Port 0)

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM110	Port 0 transmission enabling flag bit	This bit is set when XMT instruction is used, and is cleared after the transmission is over. You can manually clear this bit to halt the current transmission at Port 0. The transmission can resume when power flow is on again	R/W	√	√
SM111	Port 0 reception enabling flag bit	This bit is set when RCV instruction is used, and is cleared after the transmission is over. You can manually clear this bit to halt the current transmission at Port 0. The transmission can resume when power flow is on again	R/W	√	√
SM112	Port 0 transmission complete flag bit	This bit is set after the transmission is over	R/W	√	√
SM113	Port 0 reception complete flag bit	This bit is set after the reception is over	R/W	√	√
SM114	Port 0 idle flag bit	This bit is set when the port is idle	R	√	√

Note

SM112 ~ SM114 are the flags for the reception, complete and idle states in all communication protocols that are supported by PORT 0. For example, the PORT 0 of IVC1 PLC supports N:N bus, Modbus and Freeport. No matter which protocol is used, the functions of SM112 ~ SM114 remain the same.

8. Free Port (Port 1)

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM120	Port 1 transmission enabling flag bit	This bit is set when XMT instruction is used, and is cleared after the transmission is over. You can manually clear this bit to halt the current transmission at Port 1. The transmission can resume when power flow is on again	R/W	√	√
SM121	Port 1 reception enabling flag bit	This bit is set when RCV instruction is used, and is cleared after the transmission is over. You can manually clear this bit to halt the current transmission at Port 1. The transmission can resume when power flow is on again	R/W	√	√
SM122	Port 1 transmission complete flag bit	This bit is set after the transmission is over	R/W	√	√
SM123	Port 1 reception complete flag bit	This bit is set after the reception is over	R/W	√	√
SM124	Port 1 idle flag bit	This bit is set when the port is idle	R	√	√

Note

SM122 ~ SM124 are the flags for the reception, complete and idle states in all communication protocols that are supported by Port 1 . For example, the Port 1 of IVC1 PLC supports N:N bus, Modbus and Freeport. No matter which protocol is used, the functions of SM122 ~ SM124 remain the same.

9. Modbus Communication

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM135	Modbus communication complete	This bit is set after the communication is over	R/W	√	√
SM136	Modbus communication error	This bit is set upon communication error	R/W	√	√

10. N:N bus Communication

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM140	Station 0 communication error flag		R		√
SM141	Station 1 communication error flag		R		√
SM142	Station 2 communication error flag		R		√
SM143	Station 3 communication error flag		R		√
SM144	Station 4 communication error flag		R		√
SM145	Station 5 communication error flag		R		√
SM146	Station 6 communication error flag		R		√
SM147	Station 7 communication error flag		R		√
SM148	Station 8 communication error flag		R		√
SM149	Station 9 communication error flag		R		√
SM150	Station 10 communication error flag		R		√
SM151	Station 11 communication error flag		R		√
SM152	Station 12 communication error flag		R		√
SM153	Station 13 communication error flag		R		√
SM154	Station 14 communication error flag		R		√
SM155	Station 15 communication error flag		R		√
SM156	Station 16 communication error flag		R		√
SM157	Station 17 communication error flag		R		√
SM158	Station 18 communication error flag		R		√
SM159	Station 19 communication error flag		R		√
SM160	Station 20 communication error flag		R		√
SM161	Station 21 communication error flag		R		√
SM162	Station 22 communication error flag		R		√
SM163	Station 23 communication error flag		R		√
SM164	Station 24 communication error flag		R		√
SM165	Station 25 communication error flag		R		√
SM166	Station 26 communication error flag		R		√
SM167	Station 27 communication error flag		R		√
SM168	Station 28 communication error flag		R		√
SM169	Station 29 communication error flag		R		√
SM170	Station 31 communication error flag		R		√
SM171	Station 32 communication error flag		R		√

11. Enabling Flag Of Integrated Analog Channel

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM172	Enabling flag of AD channel 0	Sampling at AD channel 0 is enabled when this bit is set to 1	R/W		√
SM173	Enabling flag of AD channel 1	Sampling at AD channel 1 is enabled when this bit is set to 1	R/W		√
SM174	Voltage/current enabling flag of AD channel 0	1 for current input and 0 for voltage input	R/W		√
SM175	Voltage/current enabling flag of AD channel 1	1 for current input and 0 for voltage input	R/W		√
SM178	Enabling flag of DA channel 0	Output at DA channel 0 is enabled when this bit is set to 1	R/W		√

12. Operation Flag Bit

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM180	Zero flag bit	This bit is set when the related calculation result is zero. You can clear or set this bit manually	R/W	√	√
SM181	Carry/overflow flag bit	This bit is set when the result of the related calculation is a carry. You can clear or set this bit manually	R/W	√	√
SM182	borrow flag bit	This bit is set when the result of the related calculation is a borrow. You can clear or set this bit manually	R/W	√	√
SM185	Table comparison flag	This bit is set when the whole table is completed	R/W	√	√

13. ASCII Code Conversion Instruction Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM186	ASC instruction storing mode flag	0: the most and least significant bytes of every word are stored with one ASCII code 1: the least significant byte of every word is stored with one ASCII code	R/W		√

14. System Bus Error Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM190	Basic module bus error flag bit	The bit, when set 1, would stop the system. You can reset this bit by: 1. Powering-on the PLC again 2. Changing PLC status from STOP to RUN 3. Downloading a new program	R	√	√
SM191	General module bus error flag bit	1. This bit is set and the system raises an alarm when a general module bus operation error occurs 2. This bit is reset automatically when the system error is removed	R	√	√
SM192	Special module bus error flag bit	1. This bit is set and the system raises an alarm when a special module bus operation error occurs 2. This bit is reset automatically when the system error is removed	R	√	√

15. Real-Time Clock Error Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM193	R/W of real time clock error	This bit is set upon real-time clock error This bit is automatically cleared if system fault is removed	R	√	√

16. EEPROM Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SM196	EEPROM write OK flag	This bit is set when EEPROM is not being written	R		√

17. Counting Direction Of Bi-directional Counters

Addr.	Counter addr.	Function	R/W	IVC2	IVC1
SM200	C200	When SM2 _ _ is of high level, the corresponding C2_ _ becomes a down counter When SM2 _ _ is of low level, the corresponding C2_ _ becomes a up counter	R/W	√	√
SM201	C201		R/W	√	√
SM202	C202		R/W	√	√
SM203	C203		R/W	√	√
SM204	C204		R/W	√	√
SM205	C205		R/W	√	√
SM206	C206		R/W	√	√
SM207	C207		R/W	√	√
SM208	C208		R/W	√	√
SM209	C209		R/W	√	√
SM210	C210		R/W	√	√
SM211	C211		R/W	√	√
SM212	C212		R/W	√	√
SM213	C213		R/W	√	√
SM214	C214		R/W	√	√
SM215	C215		R/W	√	√
SM216	C216		R/W	√	√
SM217	C217		R/W	√	√
SM218	C218		R/W	√	√
SM219	C219		R/W	√	√
SM220	C220		R/W	√	√
SM221	C221		R/W	√	√
SM222	C222		R/W	√	√
SM223	C223		R/W	√	√
SM224	C224		R/W	√	√
SM225	C225		R/W	√	√
SM226	C226		R/W	√	√
SM227	C227		R/W	√	√
SM228	C228		R/W	√	√
SM229	C229		R/W	√	√
SM230	C230		R/W	√	√
SM231	C231		R/W	√	√
SM232	C232		R/W	√	√
SM233	C233		R/W	√	√
SM234	C234		R/W	√	√
SM235	C235		R/W	√	√

18. Counting Direction And Monitoring Of High Speed Counter

Type	Addr.	Name	Register content	R/W	IVC2	IVC1
Single phase single point counting input	SM236	C236	The high & low level of SM2 _ _ corresponds to the counting down & up of the counter respectively	R/W	√	√
	SM237	C237		R/W	√	√
	SM238	C238		R/W	√	√
	SM239	C239		R/W	√	√
	SM240	C240		R/W	√	√
	SM241	C241		R/W	√	√
	SM242	C242		R/W	√	√
	SM243	C243		R/W	√	√
	SM244	C244		R/W	√	√
Single phase bidirect-ional counting input	SM245	C245	When the single phase bi-directional counter and 2-phase counter C2 _ _ is in the down counting mode, the corresponding SM2 _ _ becomes high level; when in up counting mode, the corresponding SM2 _ _ becomes low level	R/W	√	√
	SM246	C246		R/W	√	√
	SM247	C247		R/W	√	√
	SM248	C248		R/W	√	√
	SM249	C249		R/W	√	√
AB phase counting input	SM250	C250		R/W	√	√
	SM251	C251		R/W	√	√
	SM252	C252		R/W	√	√
	SM253	C253		R/W	√	√
	SM254	C254		R/W	√	√
	SM255	C255		R/W	√	√

Appendix 2 Special Data Register

Note

1. All special data registers except SD50 ~ SD55 will be initialized when the PLC changes from STOP to RUN.
2. The reserved SD and SM elements are not listed in the table. The reserved SD elements are by default read only.

1. PLC Work State Data

Addr.	Name	Action and function	R/W	IVC2	IVC1	Range
SD00	PLC type	20 means IVC2	R	√	√	
SD01	Version	For example, 100 means V1.00	R	√	√	
SD02	Capacity of user program	For example, 8 means an 8k step program	R	√	√	
SD03	System error code	Store the code of occured system error	R	√	√	
SD04	Battery voltage	For example 36 means 3.6V	R	√	√	
SD05	Setting of AC power failure detection delay	Configurable only through system block. Any setting smaller than 10ms or bigger than 100ms will be regarded as 10ms or 100ms respectively	R	√	√	10 ~ 100ms
SD07	Number of extension I/O module		R	√	√	
SD08	Number of special module		R	√	√	
SD09	Setting the input points for operation control. Decimal (X0 is displayed as 0; X10, 8. Maximum:15). Configurable through system block		R	√	√	√
SD10	Number of basic module I/O points	The most significant byte: input. The least significant byte: output	R	√	√	
SD11	Number of extension module I/O points	The most significant byte: input. The least significant byte: output	R	√	√	
SD12	Number of basic module analog I/O points	The most significant byte: input. The least significant byte: output	R	V1.29	√	

2. Operation Error Code FIFO Area

Addr.	Name	Action and function	R/W	IVC2	IVC1	Range
SD20	Reserved operation error code 0	In the order of arrival, the latest five operation error codes are reserved. SD20 always stores the latest error codes	R	√	√	
SD21	Reserved operation error code 1		R	√	√	
SD22	Reserved operation error code 2		R	√	√	
SD23	Reserved operation error code 3		R	√	√	
SD24	Reserved operation error code 4		R	√	√	

3. FROM/TO Error

Addr.	Name	R/W	IVC2	IVC1	Range
SD25	Special modules' numbering is wrong (starting with 0) when using FROM/TO instruction	R	√	√	Initial value: 255
SD26	The I/O chips' numbering is wrong (starting with 0) when refreshing I/O	R	√	√	Initial value: 255

4. Scan Time

Addr.	Name	Action and function	R/W	IVC2	IVC1	Range
SD30	Current scan value	Current scan time (unit: ms)	R	√	√	
SD31	Min. scan time	Min. scan time (uint: ms)	R	√	√	
SD32	Max. scan time	Max. scan time (unit: ms)	R	√	√	
SD33	Constant scan time	Default: 0ms. Unit: 1ms. When the constant scan time is longer than the user monitoring overtime setting, user program overtime alarm will be raised. When a scan cycle of user program is longer than the constant scan time, the cycle constant scan mode is invalid automatically and no alarm will be raised. SD33 is regarded as 1000ms when it is set bigger than 1000ms (configurable only through the system block)	R	√	√	0 ~ 1000ms
SD34	User program overtime	Default: 100ms. Unit: 1ms. Any setting smaller than 100 or bigger than 1000 will be regarded as 100 or 1000 respectively. Configurable only through system block	R	√	√	100 ~ 1000ms

Note

1. The error tolerance of SD30, SD31 and SD32 is 1ms.
2. It is recommended to set the user program overtime (SD34) at least 5ms bigger than the constant scan time (SD33). Otherwise, due to the influence of system operation and user program, the system is apt to report user program overtime error.

5. Input Filtering Constant Setting

Addr.	Name	Action and function	R/W	IVC2	IVC1	Range
SD35	Input filtering constant	Configurable only through system block	R	√	√	0 ~ 60

6. High-speed Pulse Output Monitoring

5. SD50:.

SD54: the MSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

SD55: the LSB of the total output pulse number at Y0 and Y1 for PLSY and PLSR instructions.

Addr.	Name	R/W	IVC2	IVC1	Range
SD50	Output pulse number at Y0 for PLSY and PLSR instructions (MSB)	R/W	√	√	
SD51	Output pulse number at Y0 for PLSY and PLSR instructions (LSB)	R/W	√	√	
SD52	Output pulse number at Y1 for PLSY and PLSR instructions (MSB)	R/W	√	√	
SD53	Output pulse number at Y1 for PLSY and PLSR instructions (LSB)	R/W	√	√	
SD54	Total output pulse number at Y0 and Y1 for PLSY and PLSR instructions (MSB)	R/W	√	√	
SD55	Total output pulse number at Y0 and Y1 for PLSY and PLSR instructions (LSB)	R/W	√	√	
SD56	Current section of the PLS instruction that outputs Y0	R		√	
SD57	Current section of the PLS instruction that outputs Y1	R		√	

7. Timed Interrupt Cycle

Addr.	Name	Register content	R/W	IVC2	IVC1	Range
SD66	Cycle of timed interrupt 0	The interrupt will not occur when the value is not within 1 ~ 32767	R/W	√	√	1 ~ 32767ms
SD67	Cycle of timed interrupt 1	The interrupt will not occur when the value is not within 1 ~ 32767	R/W	√	√	1 ~ 32767ms
SD68	Cycle of timed interrupt 2	The interrupt will not occur when the value is not within 1 ~ 32767	R/W	√	√	1 ~ 32767ms

Note:

An error of ±1ms may occur when the system processes a user timed interrupt. To ensure the normal operation of the interrupt, it is recommended to set the cycle of timed interrupts to be bigger or equal to 5ms.

8. Locating Instruction

Addr.	Name	R/W	IVC2	IVC1	Initial value
SD80	The current value of Y0 output locating instruction (MSB)	R/W	V1.29	√	0
SD81	The current value of Y0 output locating instruction (LSB)	R/W	V1.29	√	
SD82	The current value of Y1 output locating instruction (MSB)	R/W	V1.29	√	0
SD83	The current value of Y1 output locating instruction (LSB)	R/W	V1.29	√	
SD84	Basic frequency of executing of instructions ZRN, DRVI and DRVA	R/W	V1.29	√	0
SD85	Highest frequency of executing of instructions ZRN, DRVI and DRVA (MSB)	R/W	V1.29	√	100.000
SD86	Highest frequency of executing of instructions ZRN, DRVI and DRVA (LSB)	R/W	V1.29	√	
SD87	Acceleration or deceleration time of executing of instructions ZRN, DRVI and DRVA	R/W	V1.29	√	100
SD88	Envelope rising time (ms)	R/W	V1.29	√	100
SD89	Envelope falling time (ms)	R/W	V1.29	√	100

9. Real-Time Clock

Addr.	Name	Register content	R/W	IVC2	IVC1	Range
SD100	Year	For real-time clock	R	√	√	2000 ~ 2099
SD101	Month	For real-time clock	R	√	√	1 ~ 12 months
SD102	Day	For real-time clock	R	√	√	1 ~ 31 days
SD103	Hour	For real-time clock	R	√	√	0 ~ 23 hours
SD104	Minute	For real-time clock	R	√	√	0 ~ 59 minutes
SD105	Second	For real-time clock	R	√	√	0 ~ 59 seconds
SD106	Week	For real-time clock	R	√	√	0 (Sunday) ~ 6 (Saturday)
Note: You can set these elements only with the TWR instruction or through the host computer						

10. Reception Control And State Of Free Port (Port 0)

Addr.	Name		Register content	R/W	IVC2	IVC1	Range
SD110	Free port 0 mode state word	SD110.0 ~ SD110.2 port baud rate	b2, b1, b0 000 = 38,400 001 = 19,200 010 = 9,600 011 = 4,800 100 = 2,400 101 = 1,200 110=57,600 111=115,200	R	√	√	
		SD110.3 Stop bit	0 = 1 stop bit 1 = 2 stop bits				
		SD110.4 parity check	0 = even parity 1 = odd parity				
		SD110.5 parity check enabling	0 = no check 1 = check				
		SD110.6 Character data bit	Data bit of every character 0 = 8 bits 1 = 7 bits				
		SD110.7 free-port receiving start mode	1 = start character specified 0 = start character unspecified				
		SD110.8 free-port receiving end mode	1 = end character specified 0 = end character unspecified				
		SD110.9 Free-port word overtime enabling	1: word overtime enabled 0: word overtime disabled				
		SD110.10 free-port frame overtime enabling	1 = frame overtime enabled 0 = frame overtime disabled				
		SD110.11	Reserved				
		SD110.12 the most/least significant byte valid	0: word register valid at LSB 1: word register valid at both MSB and LSB				
		SD110.13 ~ SD110.15	Reserved				
SD111	Start character			R/W	√	√	
SD112	End character			R/W	√	√	
SD113	Word overtime setting		Default: 0ms (word overtime omitted)	R/W	√	√	1 ~ 32767ms
SD114	Frame overtime setting		Default: 0ms (frame overtime omitted)	R/W	√	√	1 ~ 32767ms
SD115	Receiving completion message code		Bit 0: set when receiving ends Bit 1: set when specified end character is received Bit 2: set when max. character number is received Bit 3: set upon word overtime Bit 4: set upon frame overtime Bit 5: set upon parity check error Bits 6 ~ 15: reserved	R	√	√	
SD116	Characters currently received			R	√	√	
SD117	Total number of currently received characters			R	√	√	
SD118	Characters currently sent			R		√	

11. Freeport Reception Control And State (Port 1)

Addr.	Name		Register content	R/W	IVC2	IVC1	Range
SD120	Free port 1 mode state word	SD120.0 ~ SD120.2 Port baud rate	b2, b1, b0 000 = 38,400 001 = 19,200 010 = 9,600 011 = 4,800 100 = 2,400 101 = 1,200 110=57,600 111=115,200	R	√	√	
		SD120.3 stop bit	0 = 1 stop bit 1 = 2 stop bits				
		SD120.4 parity check	0 = even parity 1 = odd parity				
		SD120.5 parity check enabling	0 = disabled 1 = enabled				
		SD120.6 data bit of every character	Data bit of every character 0: 8-bit character 1: 7-bit character				
		SD120.7 free-port receiving start-character mode	1: start-character specified 0: start-character unspecified				
		SD120.8 free-port receiving end-character mode	1: end-character specified 0: end-character unspecified				
		SD120.9 free port word overtime enabling	1: word overtime enabled 0: word overtime disabled				
		SD120. 10 free port frame overtime enabling	1: frame overtime enabled 0: frame overtime disabled				
		SD120.11	Reserved				
		SD120.12 the most/least significant byte valid	0: word register valid at LSB 1: word register valid at both the most and LSBs				
		SD120.13 ~ SD120.15	Reserved				
SD121	Start character			R/W	√	√	
SD122	End character			R/W	√	√	
SD123	Word overtime setting		Default: 0ms (word overtime omitted)	R/W	√	√	0 ~ 32767ms
SD124	Frame overtime setting		Default: 0ms (frame overtime omitted)	R/W	√	√	0 ~ 32767ms
SD125	Receiving completion message code		Bit 0: set when receiving ends Bit 1: set when specified end character is received Bit 2: set when max. character number is received Bit 3: set upon word overtime Bit 4: set upon frame overtime Bit 5: set upon parity check error Bits 6 ~ 15: reserved	R	√	√	
SD126	Characters currently recived			R	√	√	
SD127	Total number of currently received characters			R	√	√	
SD128	Characters currently sent			R	V1.29	√	

12. Modbus/N:N bus Setting

Addr.	Name	R/W	IVC2	IVC1	Range
SD130	Local station No. (PORT 0)	R/W	√	√	MOD (1 ~ 32) , EMR (0 ~ 31)
SD131	Max. timeout time of PORT 0 (post-sending and pre-receiving) / N:N bus extra delay	R/W		√	
SD132	PORT 0 retry times	R/W		√	
SD133	N:N bus network update mode (PORT 0)	R/W		√	1 ~ 13
SD135	Local station No. (Port 1)	R/W	√	√	MOD (1 ~ 32), EMR (0 ~ 31)
SD136	Max. timeout time of Port 1 (post-sending and pre-receiving) /N:N bus extra delay	R/W	√	√	
SD137	Port 1 retry times	R/W	√	√	0 ~ 100
SD138	N:N bus network update mode (Port 1)	R/W	√	√	1 ~ 13
SD139	Error code of Modbus master (Port 1)	R	√	√	

13. Setting & Reading Of Integrated Analog Signal Channel

Addr.	Name	R/W	IVC2	IVC1	Range
SD172	Average sample value of AD CH0	R		√	
SD173	Sampling times of AD CH0	R/W		√	0 ~ 1000
SD174	Average sample value of AD CH1	R		√	
SD175	Sampling times of AD CH1	R/W		√	0 ~ 1000
SD178	Output value of DA CH0	R/W		√	

14. Usage Of DHSP And DHST Instructions

Addr.	Name	R/W	IVC2	IVC1	Range
SD180	MSB of DHSP table comparison output data	R/W	√	√	
SD181	LSB of DHSP table comparison output data	R/W	√	√	
SD182	MSB of DHST or DHSP table comparison data	R/W	√	√	
SD183	LSB of DHST or DHSP table comparison data	R/W	√	√	
SD184	Record No. of the table being executed	R/W	√	√	

15. Error Flag

Addr.	Name	Action and function	R/W	IVC2	IVC1
SD191	No. of the module where bus error occured	No. of the module where bus operation error occurred	R		√
SD192	No. of the special module where bus error occured	No. of the special module where bus operation error occured	R		√

Appendix 3 Reserved Elements

Start addr.	End addr.	Remark
D7940	D7969	Buffer area for transmission of inverter instructions
D7970	D7999	Buffer area for reception of inverter instructions
D7700	D7763	N:N bus network shared area
M1400	M1911	N:N bus network shared area
D6000	D6999	EROMWR instruction operation area

Note

See the related instruction and function description for the usage of the elements in the preceding table.

Appendix 4 Modbus Communication Error Code

Error codes	Description
0x01	Illegal functional code
0x02	Illegal register address
0x03	Data number error
0x10	Communication overtime (longer than the preset maximum communication time)
0x11	Data frame reception error
0x12	Parameter error (mode or master/slave parameter setting error)
0x13	Error occurs because the local station number coincides with the instruction-set station number
0x14	Element address overflow (the data received or sent is too much for the stroring area)

Appendix 5 Inverter Instruction Error Code

Error code	Description
0x1	Illegal functional code
0x2	Illegal register address
0x3	Data error (data outside the range)
0x4	Slave operation failure (including the error due to invalid data, although the data is in the range)
0x5	Valid instruction. Processing. Mainly used to save data to EEPROM
0x6	Slave busy. Please try again later. Mainly used to save data to EEPROM
0x18	Information fram error, including information length error and parity check error
0x20	Parameter unchangeable
0x21	Parameter unchangeable during operation (applicable to only EV3100)
0x22	Password protected

Appendix 6 System Error Code

Error code	Description	Error type	Description	IVC1	IVC2
0	No error			√	√
1 ~ 9	Reserved			√	√
System hardware error					
10	SRAM error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
11	FLASH error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
12	Communication port error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
13	Real-time clock error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
14	I2C error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
External setting error (20 ~ 23)					
20	Serious local I/O error	System error	User program stops, and ERR indicator turns on. To remove this fault, power off the PLC and check the hardware	√	
21	Serious extension I/O error	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
22	Serious special module error	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
23	Update error of real-time clock (incorrect time is read during system update)	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
24	EEPROM write / read operation error	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
25	Local analog signal error	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
26	System special module configuration error	System error	ERR indicator blinks. This alarm is cleared automatically upon the removal of the fault	√	
Storage error (40 ~ 45)					
40	User program file error	System error	User program stops, and ERR indicator turns on. To remove this fault, download new program or format the disk	√	√
41	System configuration file error	System error	User program stops, and ERR indicator turns on. To remove this fault, download new system configuration files or format the disk	√	√
42	Data block file error	System error	User program stops, and ERR indicator turns on. To remove this fault, download new data block file or format the disk	√	√
43	Battery-backed data lost	System error	User program keeps running ERR indicator blinks. To remove this fault, clear the register, or format the disk, or reset	√	√
44	Forced-table lost	System error	User program keeps running. ERR indicator blinks. To remove this fault, clear the register, or force, or format the disk, or reset	√	√
45	User information file error	System error	User program keeps running ERR indicator is off. To remove this fault, download new program and data block files, or format the disk	√	√
46 ~ 59	Reserved				

Error code	Description	Error type	Description	IVC1	IVC2
Instruction execution error (60～75)					
60	User program compilation error	Execution error	User program stops, and ERR indicator turns on.	√	√
61	User program operation overtime error	Execution error	User program stops, and ERR indicator turns on.	√	√
62	illegal user program instruction execution error	Execution error	User program stops, and ERR indicator turns on.	√	√
63	Illegal element type of instruciton operand	Execution error	User program stops, and ERR indicator turns on.	√	√
64	Illegal instruction operand value	Execution error	User program keeps running, ERR indicator keeps off. The corresponding error code will be prompted in SD20	√	√
65	Outside instruction element range	Execution error		√	√
66	Subprogram stack overflow	Execution error		√	√
67	User interrupt request queue overflow	Execution error		√	√
68	Illegal label jump or subprogram call	Execution error		√	√
69	Divided by 0 error	Execution error		√	√
70	Definition error of stack operated	Execution error	When stack size, or stack elements are smaller than zero, or stack element number exceeds the limit of stack size	√	√
71	Reserved			√	√
72	Undefined user subprogram or interrupt subprogram	Execution error		√	√
73	Using FROM/TO instruciton to access module not existing	Execution error			√
74	I/O error when using FROM/TO instruction	Execution error			√
75	I/O error when using REF instruction	Execution error		√	√
76	Cannot set real time clock time using TWR	Execution error		√	√
77	Parameter 3 of PLSR instruction inappropriate under constant scan	Execution error		√	√
78	BFM unit of accessed special module exceeds range	Execution error			√
79	ABS Data Read Timeout	Execution error		√	
80	ABS Data Read and Check Error	Execution error		√	

Appendix 7 Modbus Communication Protocol (IVC Series)

1. Modbus Communication Protocol Overview

IVC series small PLC has two communication ports: PORT 0 (also the programming port), which supports Modbus slave station, and Port 1 , which supports Modbus master station and slave station (configurable through ConstrolStar). Their features include:

1. Using RS485 or RS232 port, with RS-232 3-line system as the physical interface.
2. Supportive of RTU mode and ASCII mode, but not of the change of the ASCII ending character.
3. Being the Modbus slave station, the addresses range from 1 to 31.
4. Supportive of broadcast mode. The broadcast is effective for write and sub-function codes of diagnosis.
5. Suppoting baud rates including 38,400 bps, 19,200 bps, 9,600 bps, 4,800 bps, 2,400 bps and 1,200 bps. (Default: 19200, 8 bits, 1 stop bit, even check)
6. Supportive of data field 2 × 252 bytes (ASII mode) or 252 bytes (RTU mode).

2. Supported Modbus Function Code and Element Addressing

The slave station supports function codes 01, 02, 03, 05, 06, 08, 15, 16 (decimal).

Pay attention to the following points during the reading:

Relationship between read-write element function code and the element

Function code	Name of function code	Modicon data address	Type of operational element	Remark
01	read coil status	0[Note 1]:xxxx	Y, X, M, SM, S, T, C	Bit read
02	read discrete input status	1 [Note 2]:xxxx	X	Bit read
03	read register status	4 [Note 3]:xxxx [Note 4]	D, SD, Z, T, C	Word read
05	write single coil status	0:xxxx	Y, M, SM, S, T, C	Word write
06	write single register status	4:xxxx	D, SD, Z, T, C	Word write
15	write multiple coils status	0:xxxx	Y, M, SM, S, T, C	Bit write
16	write multiple registers status	4:xxxx	D, SD, Z, T, C	Word write

Note:
1. 0 means “coil”.
2. 1 means “discrete input”.
3. 4 means “register”.
4. xxxx means range “1 ~ 9999”. Each type has an independent logic address range of 1 to 9999 (protocol address starts from 0).
5. 0, 1 and 4 do not have the physical meaning and are not involved in actual addressing.
6. Users shall not write X element with function codes 05 and 15; otherwise, the system will not feed back the error information if the written operand and data are correct, but the system will not perform any operation on the write instruction.

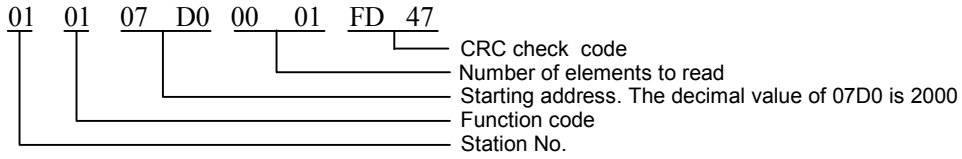
Relationship between PLC Element and Modbus Communication Protocol Address

Element	Type	Physical element	Protocol address	Supported function code	Notes
Y	bit	Y0 to Y377 (octal code) 256 points in total	0000 ~ 0255	01, 05, 15	output status, element code: Y0 ~ Y7, Y10 ~ Y17
X	bit	X0 to X377 (octal code) 256 points in total	1200 ~ 01455 0000 ~ 0255	01, 05, 15 02	input status, it supports two kinds of address, the element code is same as above
M	bit	M0 to M1999	2000 ~ 3999	01, 05, 15	
SM	bit	SM0 to SM255	4400 ~4655	01, 05, 15	
S	bit	S0 ~ S991	6000 ~ 6991	01, 05, 15	
T	bit	T0 ~ T255	8000 ~ 8255	01, 05, 15	status of T element
C	bit	C0 ~ C255	9200 ~ 9455	01, 05, 15	status of C element
D	word	D0 ~ D7999	0000 ~ 7999	03, 06, 16	
SD	word	SD0 ~ SD255	8000 ~ 8255	03, 06, 16	
Z	word	Z0 ~ Z15	8500 ~ 8515	03, 06, 16	

Element	Type	Physical element	Protocol address	Supported function code	Notes
T	word	T0 ~ T255	9000 ~ 9255	03, 06, 16	current value of T element
C	word	C0 ~ C199	9500 ~ 9699	03, 06, 16	current value of C element (WORD)
C	Double word	C200 ~ C255	9700 ~ 9811	03, 16	current value of C element (WORD)

Note:

The protocol address is the address used on data transfer and corresponds with the logic address of Modicon data. The protocol address starts from 0 and the logic address of Modicon data begins with 1, that is, protocol address + 1 = logic address of Modicon data. For example, if M0 protocol address is 2000, and its corresponding logic address of Modicon data will be 0:2001. In practice, the read and write of M0 is completed through the protocol address, for example: read M0 element frame (sent from the master):


01 01 07 D0 00 01 FD 47
CRC check code
Number of elements to read
Starting address. The decimal value of 07D0 is 2000
Function code
Station No.

Abnormal response description:

Abnormal code	Definition
0x01	Illegal function code
0x02	Illegal register address
0x03	Illegal data

Note the following:

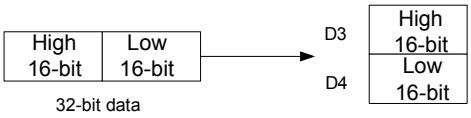
1. Elements X and Y use octal system. There are 256 points in total from X0 to X377, 256 points from Y0 to Y377, with the combinations of Y0 ~ Y7, Y10 ~ Y17 and Y20 ~ Y27. etc.

2. Two addressing methods are available for Element X. One is the protocol address of 1200-1455 with corresponding function codes of 01, 05 and 15; the other is the protocol address of 0-255 with function code 02.

3. Processing of double-word element: C element is a counter. It has status and current value. C200 ~ C255 are 32-bit elements, but each C element in the range will get two protocol addresses during the protocol address compiling. For example: The protocol address of C200 is 9700 ~ 9701. When reading the elements though Modbus, both the starting protocol address and the number of the read elements shall be even number.

4. For most SM, SD elements, the real value cannot be written through Modbus, but PLC salve station will still return “OK“ to indicate the completion of write operation, which is allowable.

5. In addition, the Modbus communication protocol of IVC2 supports the read and write of double word element, LONG INT variable and floating point number. In the PLC of IVC2, 32-bit data are stored with high bits at high address. For example, a 32-bit data is stored in two D elements (D3 and D4), with 16 high bits in D3 and 16 low bits in D4, as shown in the following figure: (Refer to the description for the specific example)



3. Modbus Function Code Description

3.1 Read coil status (0x01)

Up to 256 bit-element can be read in IVC series PLC.

1. Request frame

Address	Function code (01H)	Initial address		Number of elements		Check code (CRC or LRC)
		H	L	H	L	

2. Response frame

If the read address is not the times of 8, the remaining bits will be filled with 0 (starting with the high bits).

Address	Function code (01H)	Number of bytes read (n)	Read data No.1	.....	Read data No.n	Check code (CRC or LRC

B7	B6	B5	B4	B3	B2	B1	B0

3.2 Read discrete input status (0x02)

In the PLC of GCM series, it specially refers to X element. The function code only supports the read function of X element with the maximum read number of 256.

1. Request frame

Address	Function code (02H)	starting address		Number of elements		Check code (CRC or LRC)
		H	L	H	L	

2. Response frame

If the read address is not the times of 8, the remaining bits will be filled with 0 (starting with the high bits).

Address	Function code (02H)	Number of bytes read (n)	Read data No.1	...	Read data No.n	Check code (CRC or LRC

B7	B6	B5	B4	B3	B2	B1	B0

3.3 Read Holding Registers (0x03)

It refers to reading the value of data (word) register at the slave station, with the maximum number of registers of 125 read each time. It does not support broadcast.

1. Request frame

Address	Function Code (03H)	Starting address		Number of elements		Check code (CRC or LRC)
		H	L	H	L	

2. Response frame

Address	Function code (03H)	Number of bytes read (n)	Read data No.1		...	Read data No.n		Check code (CRC or LRC)
			H	L		H	L	

3.4 Force (Write) Single Coil (0x05)

Force (Write) single coil writes bit element value to the slave station and supports broadcast, i.e. writing the same element to all slave stations. It supports 1 bit element at most.

1. Request frame

Address	Function Code (05H)	Starting address		Written element value		Check code (CRC or LRC)
		H	L	H	L	

Note: The written value of the element is 0xFF00 (ON, 1) or 0x0000 (OFF, 0).

2. Response frame

Response frame is the repeat of request frame.

Address	Function code (05H)	Starting address		Written element value		Check code (CRC or LRC)
		H	L	H	L	

3.5 Preset (write) Single Register (0x06)

Preset (Write) single register writes word element value to the slave station and supports broadcast, i.e. writing the same element to all slave stations. It supports 1 bit element at most.

1. Request frame

Address	Function code (06H)	Starting address		Written element value		Check code
		H	L	H	L	(CRC or LRC)

2. Response frame

Response frame is the repeat of Request frame.

Address	Function code (06H)	Starting address		Written element value		Check code
		H	L	H	L	(CRC or LRC)

3.6 Return Diagnostic Check (0 x 08)

Diagnostic register and communication error information can be obtained through returning diagnostic check.

Diagnostic code	Description
0x00	Return Request frame
0x 01	Restart Comm Option
0x 04	Listen Only Mode of Slave Station
0x0a	Clear Ctrs and Diagnostic Reg
0x0b	Return Bus Message Count
0x0c	Return Bus CRC Error Count
0x0d	Return Bus Exception Error Cnt
0x0e	Return Slave Message Count
0x0f	Return Slave No Response Cnt
0x12	Return Bus Char. Overrun Cnt

The frame description of sub-function code is as follows.

Return request frame (0x00):

1. Request frame

Address	Function code (0x08H)	Function word		Any character		Check code
		(0x00H)	(0x00H)	H	L	(CRC or LRC)

2. Response frame

Return request frame intact.

Address	Function code (0x08H)	Function word		Any character		Check code
		(0x00H)	(0x00H)	H	L	(CRC or LRC)

Restart communication option (0x01):

After receiving the frame, PLC will exit from Listen Only mode (Broadcast frame is supported).

1. Request frame

The normal Data field is 0x00 00 or 0xff 00.

Address	Function code (0x08H)	Function word		Data field		Check code
		0x00H	0x01H	H	L	(CRC or LRC)

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code
		0x00H	0x01H	H	L	(CRC or LRC)

Listen only mode of slave station (0x04):

Slave station enters Listen Only mode. None of the instructions will be executed or responded. The slave station can only recognize the restart communication option instruction and enters the online mode after receiving the instruction (Broadcast frame is supported).

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x04H)	0x00H	0x00H	

2. Response frame

No return

Clear counter and diagnostic register (0x0A):

Clear all counters (Broadcast frame is supported).

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0AH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0AH)	0x00H	0x00H	

Return bus message count (0x0B):

Record the total number of the messages to all master stations from the slave stations since the last starting, clearing and power-on of counter, which excludes the message of CRC error.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0BH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0BH)	H	L	

CRC error count (0x0C):

Record the number of CRC errors received by slave station since the last starting, clearing and power-on of counter.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0CH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0CH)	H	L	

Return Slave Exception Error Count (0x0D):

Record the number of the exception error that detected by slave station since the last starting, clearing and power-on of counter, which includes the error detected in the broadcast message.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0DH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0DH)	H	L	

Return Slave Message Count (0x0E)

Record the number of the addressing messages received by the slave station since the last starting, clearing and power-on of counter.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0EH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0EH)	H	L	

Return Slave No Response Count (0x0F)

Record the number of messages that have not returned to the slave station since the last starting, clearing and power-on of counter.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0FH)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x0FH)	H	L	

Return Bus Character Overrun Count (0x12)

Record the number of the messages that cannot be addressed due to the character overrun since the last starting, clearing and power-on of counter.

1. Request frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x12H)	0x00H	0x00H	

2. Response frame

Address	Function code (0x08H)	Function word		Data field		Check code (CRC or LRC)
		(0x00H)	(0x12H)	H	L	

3.7 Force (Write) Multiple Coils (0x0F Hex)

At most 1968 bit elements (0x07b0) can be written and the number is changeable according to the defined range.

1. Request frame

Address	Function code (0FH)	Starting address		Number of elements		Number of bytes(n)	Written element value No.1	...	Written element value No.N	Check code (CRC or LRC)
		H	L	H	L					

B7	B6	B5	B4	B3	B2	B1	B0

2. Response frame

Address	Function code (0FH)	starting address		Number of elements		Check code (CRC or LRC)
		H	L	H	L	

3.8 Preset(reset) Multiple Registers (0x10 Hex)

At most 120 registers (0x78) can be written

1. Request frame

Address	Function code (0x10H)	Starting address		Number of elements		Number of bytes (n)	Written element value No.1		...	Written element value No.N		Check code (CRC or LRC)
		H	L	H	L		H	L		H	L	

2. Response frame

Address	Function code (0x10H)	Starting address		Number of elements		Check code (CRC or LRC)
		H	L	H	L	

3.9 Faulty Response Frame (0x80+function code)

Response Frame:

Address	Function code	Error code (see above)	Check code (CRC or LRC)

Function code refers to the function code of the captured request frame + 0x80

3.10 Points To Note

1. Refer to the address classification of elements, the elements read each time shall be of the same type. For example, elements X and Y cannot be read in one frame.

2. The address and data range of the element shall be within the range specified by the protocol. For example:

For Y element, the protocol address range is 0000 ~ 0255 (Y0-Y377):

- If the read starting address is 1 and 256 elements are read, address error will be returned (error code 02), because there are only 255 Y elements that start with 1.
- If the read starting address is 0 and 257 elements are read, data error will be returned (error code 03), because the actual defined number of Y elements is only 256.
- If the read starting address is 0 and 256 elements are read, the status of 256 elements will be returned.

In other words, the read number of the elements must be within the actually defined range. It is true for read/write of bit/word elements.

4. Example Of Modbus Communication Control

Rather than transmitting any message actively, the Modbus slave station only decides whether to respond to the message from the master station based on the specific situation after receiving the message for the local station. The slave station only supports Modbus function codes 01, 02, 03, 05, 06, 08, 15 and 16. The rest will be responded with illegal function code (except broadcast frame).

Read and write of element:

Except function code 08, the other supported function codes can read and write element. In principle, one frame can read up to 2000 bit elements 125 word elements, and write 1968 bit elements and 120 word elements at most. However, the real protocol addresses are separate and discontinuous for different elements, therefore, when reading or writing an element, the elements read at one time can only be the same type and the maximum number of the read or written elements is related to the actually defined number of the elements. For example, when reading Y element (Y0-Y377), the protocol address ranges from 0 to 255, the logic address of the corresponding Modicon data is 1-256 and the maximum number of elements can be read is 256. See the following examples:

Note: The address of the slave station is 01, the last two bytes are CRC check code and the second byte is function code.

1. XMT from master station: 01 01 00 00 01 00 3D 9A

   01 address; 01 function code; 00 00 starting address; 01 00 number of read elements; 3D 9A check

   Slave station response: return correct response

2. XMT from master station: 01 01 00 00 01 01 FC 5A

   The master station reads 01 01 elements (257), which is over the defined range of Y elements.

   Slave station response: 01 81 03 00 51

   The response of the slave station is illegal data, because 257>256, 256 is the allowed maximum number of Y elements.

3. XMT from master station: 01 01 00 64 00 A0 7D AD

00 64(decimal 100) is the starting address for master station to read, 00 A0 (decimal 160) is the number of the elements.

Slave station response: 01 81 02 C1 91

The response of the slave station is illegal address, because there are only 156 Y elements which are defined to start from 100 and 160 Y elements have exceeded the number.

4. XMT from master station: 01 01 01 2C 00 0A 7C 38

The master station reads 10 bit elements of 01 2C (decimal 300).

Slave station response: 01 81 02 C1 91

The response of the slave station is illegal address, because protocol address 300 has no definition of bit element.

5. XMT from master station: 01 04 00 02 00 0A D1 CD

The mater station sends the frame of function code 04.

Slave station response: 01 84 01 82 C0

The response of the slave station is illegal function code.

6. XMT from master station: 01 02 00 00 00 0A F8 0D

Master station reads input element (X element), 10 (X0-X9) from the starting address 00 00.

Slave station response: 01 02 02 00 00 B9 B8

The slave station responds with correct information, which has 02 bytes, and the content is 00 00.

7. XMT from master station: 01 01 04 B0 00 0A BC DA

Master station reads 10 bit elements(X0-X9) starting with 04 B0 (decimal 1200).

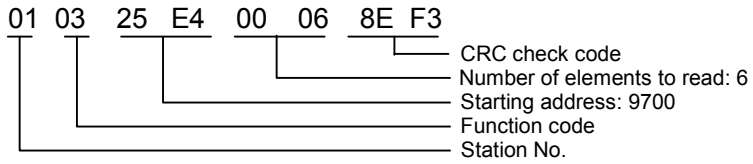
Slave station response: 01 01 02 00 00 B9 FC

Note

1. The slave station responds with 02 bytes, and the content is 00 00.
2. X element does not support write.

Processing of double-word elements

1. The current value of C element is word element or double word element. The values from C200 to C255 are double word elements, which are read and written through the function codes (03, 16) of read/write register. The address of every two registers corresponds to one C double word element, and the registers can only be read or written in pair. For example, read the RTU fame of three C double word elements (C200-C202):



In the returned data, 9700 and 9701 are the two addresses representing the content of C200. 9700 is the high 16 bits and 9701 is the low 16 bits.

2. When reading the double word element, if the starting address for the reading is not an even number, the error code of illegal address will be returned. For example:

XMT from master station: 01 03 25 E5 00 04 5E F2

The starting address for the reading sent by the master is 25 E5 (four word elements, decimal 9701).

Slave station response: 01 83 02 C0 F1

Slave station response: illegal data address

3. If the number of the read elements is not an even number, the error code of illegal data will be returned. For example:

XMT from master station: 01 03 25 E4 00 05 CE F2

25 E4: The starting address for master station reading, 5 word elements

Slave response: 01 83 03 01 31

Slave station returns illegal data.

Processing of LONG INT data:

Based on the storage method of PLC in GCM, one LONG INT data can be saved in two D elements. For example: Store one LONG INT data in D3 and D4, D3 is used for storing high 16 bits, D4 is used for storing low 16 bits in Invt PLC. If master station reads LONG INT data through Modbus, the 32-bit data shall be regrouped based on the LONG INT storage principle of INVT PLC after reading the data.

Storage principle of FLOAT is the same as the storage principle of LONG INT.

5. Description Of Broadcast

The slave station supports broadcast but not all the function codes. The slave station supports function codes 01, 02, 03, 05, 06, 08, 15 and 16 (decimal). Wherein, 01, 02 and 03 can read element but do not support broadcast, no response will be gotten after sending out the broadcast; 05, 06, 15 and 16 can write element and support broadcast, no response will be gotten after sending out the broadcast, but slave station will process the received data; 08 is the diagnostic function code, it does not support the broadcast except its sub-function codes 0x01, 0x04 and 0x0A (Hexadecimal).

Appendix 8 ASCII Code Table

ASCII HEX		High 3-bit							
		0	1	2	3	4	5	6	7
Low 4-bit	0	NUL	DLE	SPACE	0	@	P	` (pause mark)	p
	1	SOH	DC1	!	1	A	Q	a	q
	2	STX	DC2	"	2	B	R	b	r
	3	ETX	DC3	#	3	C	S	c	s
	4	EOT	DC4	$	4	D	T	d	t
	5	ENQ	NAK	%	5	E	U	e	u
	6	ACK	SYN	&	6	F	V	f	v
	7	BEL	ETB	, (single quotation marks)	7	G	W	g	w
	8	BS	CAN	(	8	H	X	h	x
	9	HT	EM	)	9	I	Y	i	y
	A	LF	SUB	*	:	J	Z	j	z
	B	VT	ESC	+	;	K	[	k	{
	C	FF	FS	, (comma)	<	L		l	l (vertical slash)
	D	CR	GS	- (subtraction sign)	=	M	]	m	}
	E	SO	RS	.	>	N	^	n	~
	F	SI	US	/	?	O	- (Underline)	o	DEL

Appendix 9 Instruction Index

Instruction		Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
A	ABS	Read current value instruction	8			√	199
	ADD	Integer math instructions	7	Zero, Carry, Borrow	√	√	89
	ANB	Power-flow block and	1		√	√	58
	AND	NO contact power-flow and	1		√	√	56
	AND<	Compare integer AND< instruction	5		√	√	185
	AND<=	Compare integer AND<= instruction	5		√	√	185
	AND<>	Compare integer AND <> instruction	5		√	√	185
	AND=	Compare integer AND= instruction	5		√	√	185
	AND>	Compare integer AND > instruction	5		√	√	185
	AND>=	Compare integer AND > =instruction	5		√	√	185
	ANDD<	Compare double integer ANDD< instruction	7		√	√	188
	ANDD<=	Compare double integer ANDD<= instruction	7		√	√	188
	ANDD<>	Compare double integer ANDD<> instruction	7		√	√	188
	ANDD=	Compare double integer ANDD= instruction	7		√	√	188
	ANDD>	Compare double integer ANDD> instruction	7		√	√	188
	ANDD>=	Compare double integer ANDD>= instruction	7		√	√	188
	ANDR<	Compare floating point number ANDR< instruction	7		√	√	191
	ANDR<=	Compare floating point number ANDR<= instruction	7		√	√	191
	ANDR<>	Compare floating point number ANDR<> instruction	7		√	√	191
	ANDR=	Compare floating point number ANDR= instruction	7		√	√	191
	ANDR>	Compare floating point number ANDR> instruction	7		√	√	191
	ANDR>=	Compare floating point number ANDR>= instruction	7		√	√	191
	ANI	NC contact power-flow and	1		√	√	56
	ASC	ASCII Code conversion instruction	19			√	113
	ATI	ASCII-hexadecimal integer conversion instruction	7			√	115
B	BAND	Word bit contactor AND instruction	5		√	√	181
	BANI	Word bit contactor ANI instruction	5		√	√	181
	BCD	Word to 16-bit BCD instruction	5		√	√	109
	BIN	16-bit BCD to word instruction	5		√	√	110
	BITS	Counting ON bit in word instruction	5		√	√	179
	BLD	Word bit contactor LD instruction	5		√	√	180
	BLDI	Word bit contactor LDI instruction	5		√	√	180
	BMOV	Move data block transmission instruction	7		√	√	81
	BOR	Word bit contactor OR instruction	5		√	√	182
	BORI	Word bit contactor ORI instruction	5		√	√	182
	BOUT	Word bit coil output instruction	5		√	√	183
	BRST	Word bit coil reset instruction	5		√	√	183
	BSET	Word bit coil set instruction	5		√	√	183
C	CALL	Calling a subprogram	Dependent on the parameter of the subprogram		√	√	79
	CCITT	CCITT check instruction	7		√	√	174
	CFEND	Conditional end from user main program	1		√	√	77
	CIRET	Conditional return from user interrupt subprogram	1		√	√	78
	CJ	Conditional jump	3		√	√	77
	COS	Floating point number COS instruction	7	Zero	√	√	103
	CRC16	CRC16 check instruction	7		√	√	175
	CSRET	Conditional return from user subprogram	1		√	√	79
	CTR	16-bit counter loop cycle counting instruction	5		√	√	68
	CTU	16-bit counter counting up instruction	5		√	√	67

Instruction		Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
	DADD	Add double integer instruction	10	Zero, Carry, Borrow	√	√	93
	DBCD	Double word to 32-bit BCD instruction	7		√	√	109
	DBIN	32-bit BCD to double word instruction	7		√	√	110
	DBITS	Counting ON bit in double word instruction	6		√	√	179
	DCMP<	Compare date< instruction	7		√	√	140
	DCMP<=	Compare date<= instruction	7		√	√	140
	DCMP<>	Compare date<> instruction	7		√	√	140
	DCMP=	Compare date= instruction	7		√	√	140
	DCMP>	Compare date> instruction	7		√	√	140
	DCMP>=	Compare date>= instruction	7		√	√	140
	DCNT	32-bit counting instruction	7		√	√	69
	DDEC	Decrement double integer instruction	4		√	√	96
	DDIV	Divide double integer instruction	10		√	√	95
	DEC	Decrement integer instruction	3		√	√	92
	DECO	Decode instruction	5		√	√	178
	DFLT	Double integer to floating point number instruction	7		√	√	107
	DFMOV	Fill data block double word instruction	9		√	√	82
	DFROM	Read double word from special module buffer register instruction	10		√	√	130
	DGBIN	32-bit gray code to double word instruction	7		√	√	112
	DGRY	Double word to 32-bit gray code instruction	7		√	√	111
	DHSCI	High-speed counting compare interrupt trigger instruction	10		√	√	144
	DHSCR	High-speed counting compare reset instruction	10		√	√	145
	DHSCS	High-speed counting compare set instruction	10		√	√	143
	DHSP	High-speed counting table compare pulse output instruction	10		√	√	149
	DHST	High-speed counting table compare instruction	10		√	√	147
D	DHSZ	High-speed counting zone compare instruction	13		√	√	146
	DI	Disable interrupt instruction	1		√	√	78
	DINC	Increment double integer instruction	4		√	√	96
	DINT	Floating point number to double integer instruction	7	Zero, Carry, Borrow	√	√	108
	DIV	Divide integer instruction	7		√	√	90
	DMOV	Move double word data transmission instruction	7		√	√	80
	DMUL	Multiply double integer instruction	10		√	√	94
	DNEG	Negative double integer instruction	7		√	√	97
	DRCL	32-bit carry circular shift left instruction	9	Carry	√	√	124
	DRCR	32-bit carry circular shift right instruction	9	Carry	√	√	123
	DROL	32-bit circular shift left instruction	9	Carry	√	√	123
	DROR	32-bit circular shift right instruction	9	Carry	√	√	122
	DRVA	Control absolute position instruction	11			√	199
	DRVI	Control relative position instruction	11			√	198
	DSHL	32-bit shift left instruction	9		√	√	126
	DSHR	32-bit shift right instruction	9		√	√	125
	DSQT	Square root double integer instruction	7		√	√	95
	DSUB	Subtract double integer instruction	10	Zero, Carry, Borrow	√	√	94
	DSUM	Sum double integer instruction	9	Zero	√	√	99
	DTI	Double integer to integer instruction	6		√	√	106
	DTO	Read double word from special module buffer register instruction	10		√	√	132
	DVABS	Double integer absolute value instruction	7		√	√	97
	DWAND	AND double word instruction	10		√	√	117
	DWINV	NOT double word Instruction	10		√	√	119
	DWOR	OR double word instruction	10		√	√	118
	DWXOR	Exclusive-OR double word instruction	10		√	√	118
	DXCH	Exchange double word instruction	7		√	√	84

Instruction		Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
E	ED	Power flow falling edge detection	1		√	√	61
	EI	Enable interrupt instruction	1		√	√	78
	ENCO	Encode instruction	5		√	√	178
	EROMWR	EEPROM write instruction	7			√	134
	EU	Power flow rising edge detection	2		√	√	60
	IVDFWD	FREQUENCY CONVERTER touch forward rotation instruction	6			√	166
	IVDREV	FREQUENCY CONVERTER touch reverse rotation instruction	6			√	167
	IVFRQ	FREQUENCY CONVERTER set frequency instruction	8			√	168
	IVFWD	FREQUENCY CONVERTER forward rotation instruction	6			√	165
	IVRD	FREQUENCY CONVERTER read single register value instruction	10			√	171
	IVRDST	FREQUENCY CONVERTER read status instruction	10			√	170
	IVREV	FREQUENCY CONVERTER reverse rotation instruction	6			√	166
	IVSTOP	FREQUENCY CONVERTER stop instruction	8			√	167
	IVWRT	FREQUENCY CONVERTER write single register value instruction	10			√	169
	EXP	Floating point number EXP instruction EXP	7	Zero, Carry	√	√	105
F	FIFO	First-in-first-out instruction	7	Zero	√	√	86
	FLT	Integer to floating point number instruction	6		√	√	107
	FMOV	Fill data block instruction	7		√	√	82
	FOR	Cycle instruction	3		√	√	75
	FROM	Read word from special module buffer register instruction	9		√	√	129
G	GBIN	16-bit gray code to word instruction	5		√	√	110
	GRY	Word to 16-bit gray code instruction	5		√	√	111
H	HACKLE	Hackle wave signal output instruction	12		√	√	161
	HCNT	High-speed counter drive instruction	7		√	√	142
	HOUR	Timing list instruction	8		√	√	139
I	INC	Increment integer instruction	3		√	√	91
	INT	Floating point number to integer instruction	6	Zero, Carry, Borrow	√	√	108
	INV	Power-flow block inverse	1		√	√	61
	ITA	hexadecimal integer-ASCII conversion instruction	7			√	114
	ITD	Integer to double integer instruction	6		√	√	107
L	LBL	Jump label definition	3		√	√	76
	LD	NO contact power-flow loading	1		√	√	55
	LD<	Compare integer LD< instruction	5		√	√	184
	LD<=	Compare integer LD<= instruction	5		√	√	184
	LD<>	Compare integer LD<> instruction	5		√	√	184
	LD=	Compare integer LD= instruction	5		√	√	184
	LD>	Compare integer LD> instruction	5		√	√	184
	LD>=	Compare integer LD>= instruction	5		√	√	184
	LDD<	Compare double integer LDD< instruction	7		√	√	187
	LDD<=	Compare double integer LDD<= instruction	7		√	√	187
	LDD<>	Compare double integer LDD<> instruction	7		√	√	187
	LDD=	Compare double integer LDD= instruction	7		√	√	187
	LDD>	Compare double integer LDD> instruction	7		√	√	187
	LDD>=	Compare double integer LDD>= instruction	7		√	√	187
	LDI	NC contact power-flow loading	1		√	√	55
	LDR<	Compare floating point number LDR< instruction	7		√	√	190
	LDR<=	Compare floating point number LDR<= instruction	7		√	√	190
	LDR<>	Compare floating point number LDR<> instruction	7		√	√	190
	LDR=	Compare floating point number LDR= instruction	7		√	√	190
	LDR>	Compare floating point number LDR> instruction	7		√	√	190

Instruction		Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
	LDR>=	Compare floating point number LDR>= instruction	7		√	√	190
	LIFO	Last-in-first-output instruction	7	Zero	√	√	86
	LN	Floating point number LN instruction	7	Zero, Carry	√	√	105
	LRC	LRC check instruction	7		√	√	176
M	MC	Main control	3		√	√	62
	MCR	Main control remove	1		√	√	63
	Modbus	Modbus master station communication instruction	8		√	√	164
	MOV	Move word data transmission instruction	5		√	√	80
	MPP	Output power-flow stack pop off	1		√	√	60
	MPS	Output power-flow input stack	1		√	√	59
	MRD	Read output power-flow stack top value	1		√	√	60
	MUL	Multiply integer instruction	8		√	√	90
N	NEG	Negative integer instruction	5		√	√	93
	NEXT	Return from cycle	1		√	√	75
	NOP	No operation	1		√	√	62
O	OR	NO contact power-flow or	1		√	√	57
	OR<	Compare integer OR< instruction	5		√	√	186
	OR<=	Compare integer OR<= instruction	5		√	√	186
	OR<>	Compare integer OR<> instruction	5		√	√	186
	OR=	Compare integer OR= instruction	5		√	√	186
	OR>	Compare integer OR> instruction	5		√	√	186
	OR>=	Compare integer OR>= instruction	5		√	√	186
	ORB	Power-flow block or	1		√	√	59
	ORD<	Compare double integer ORD< instruction	7		√	√	189
	ORD<=	Compare double integer ORD<= instruction	7		√	√	189
	ORD<>	Compare double integer ORD<> instruction	7		√	√	189
	ORD=	Compare double integer ORD= instruction	7		√	√	189
	ORD>	Compare double integer ORD> instruction	7		√	√	189
	ORD>=	Compare double integer ORD>= instruction	7		√	√	189
	ORI	NC contact power-flow or	1		√	√	57
	ORR<	Compare floating point number ORR< instruction	7		√	√	192
	ORR<=	Compare floating point number ORR<= instruction	7		√	√	192
	ORR<>	Compare floating point number ORR<> instruction	7		√	√	192
	ORR=	Compare floating point number ORR= instruction	7		√	√	192
	ORR>	Compare floating point number ORR> instruction	7		√	√	192
	ORR>=	Compare floating point number ORR>= instruction	7		√	√	192
	OUT	Power-flow output	1		√	√	58
	OUT Sxx	SFC state jumb	3		√	√	64
P	PID	PID instruction	9		√	√	157
	PLS	Pulse Output Instruction of Envelop	7			√	155
	PLSR	Count pulse with acceleration/deceleration output instruction	10		√	√	153
	PLSV	Variable speed pulse output instruction	8			√	197
	PLSY	Count pulse output instruction	9		√	√	152
	POWER	Floating point number exponentiation instruction	10	Zero, Carry	√	√	104
	PUSH	Push instruction	7	Carry	√	√	84
	PWM	PWM pulse output instruction	7		√	√	156
R	RADD	Add floating point number instruction	10	Zero, Carry	√	√	99
	RAMP	Ramp wave signal output instruction	12		√	√	160
	RCL	16-bit carry circular shift left instruction	7	Carry	√	√	122
	RCR	16-bit carry circular shift right instruction	7	Carry	√	√	121
	RCV	Free-port receiving (RCV) instruction	7		√	√	173
	RDIV	Divide floating point number instruction	10	Zero, Carry	√	√	101
	REF	Set input filtering constant instruction	5		√	√	133
	REFF	Set input filtering constant instruction	3		√	√	133
	RET	SFC program end	1		√	√	65
	RMOV	Move floating point number data transmission instruction	7		√	√	81

Instruction		Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
	RMUL	Multiply floating point number instruction	10	Zero, Carry	√	√	100
	RNEG	Negative floating point number instruction	7		√	√	102
	ROL	16-bit circular shift left instruction	7	Carry	√	√	120
R	ROR	16-bit circular shift right instruction	7	Carry	√	√	119
	RSQT	Square root floating point number instruction	7	Zero	√	√	101
	RST	Reset	1		√	√	62
	RST Sxx	SFC state delete	3		√	√	65
	RSUB	Subtract floating point number instruction	10	Zero, Carry	√	√	100
	RSUM	Sum floating point number instruction	9		√	√	106
	RVABS	Floating point number absolute value instruction	7		√	√	102
S	SEG	Word to 7-segment encode	5		√	√	113
	SET	Set	1		√	√	62
	SET Sxx	SFC state shift	3		√	√	64
	SFTL	Shift left byte instruction	9		√	√	128
	SFTR	Shift right byte instruction	9		√	√	127
	SHL	16-bit shift left instruction	7		√	√	125
	SHR	16-bit shift right word instruction	7		√	√	124
	SIN	Floating point number SIN instruction	7	Zero	√	√	103
	SPD	Pulse detection instruction	7		√	√	151
	SQT	Square root integer instructions	5		√	√	91
	STL	SFC state load instruction	3		√	√	64
	STOP	User program stop	1		√	√	78
	SUB	Subtract integer instruction	7	Zero, Carry, Borrow	√	√	89
	SUM	Sum integer instruction	8	Zero	√	√	98
	SWAP	Swap bytes	3		√	√	83
T	TADD	Add clock instruction	7	Zero, Carry	√	√	137
	TAN	Floating point number TAN instruction	7	Zero, Carry	√	√	104
	TCMP<	Compare time< instruction	7		√	√	141
	TCMP<=	Compare time>= instruction	7		√	√	141
	TCMP<>	Compare time<> instruction	7		√	√	141
	TCMP=	Compare time= instruction	7		√	√	141
	TCMP>	Compare time> instruction	7		√	√	141
	TCMP>=	Compare time>= instruction	7		√	√	141
	TMON	Monostable timing instruction	5		√	√	67
	TO	Read word from special module buffer register instruction	9		√	√	131
	TOF	Off-delay timing instruction	5		√	√	66
	TON	On-delay timing instruction	5		√	√	65
	TONR	On-delay remember timing instruction	5		√	√	66
	TRD	Read real-time clock instruction	3		√	√	135
	TRIANGLE	Triangle wave signal output instruction	12		√	√	162
	TSUB	Subtract clock instruction	7	Zero, Borrow	√	√	138
	TWR	Write real-time clock instruction	3		√	√	136
V	VABS	Integer absolute value instruction	5		√	√	92
	VRRD	Read analog potentiometer value instruction	5		√	√	132
W	WAND	AND word instruction	7		√	√	115
	WDT	User program watchdog reset	1		√	√	77
	WINV	NOT word instruction	5		√	√	117
	WOR	OR word instruction	7		√	√	116
	WSFL	Shift left word instruction	9		√	√	88
	WSFR	Shift right word instruction	9		√	√	87
	WXOR	Exclusive-OR word instruction	7		√	√	116
X	XCH	Exchange word instruction	5		√	√	83
	XMT	Free-port sending (XMT) instruction	7		√	√	172
Z	ZRN	Regress to origin instruction	11			√	196
	ZRST	Batch bit reset instruction	5		√	√	177
	ZSET	Set batch bit instruction	5		√	√	177

Appendix 10 Classified Instruction Index

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Basic instruction	LD	NO contact power-flow loading	1				55
	LDI	NC contact power-flow loading	1		√	√	55
	AND	NO contact power-flow and	1		√	√	56
	ANI	NC contact power-flow and	1		√	√	56
	OR	NO contact power-flow or	1		√	√	57
	ORI	NC contact power-flow or	1		√	√	57
	OUT	Power-flow output	1		√	√	58
	SET	Set	1		√	√	62
	RST	Reset	1		√	√	62
	ANB	Power-flow block and	1		√	√	58
	ORB	Power-flow block or	1		√	√	59
	INV	Power-flow block inverse	1		√	√	61
	NOP	No operation	1		√	√	62
	MPS	Output power-flow input stack	1		√	√	59
	MRD	Read output power-flow stack top value	1		√	√	60
	MPP	Output power-flow stack pop off	1		√	√	60
	MC	Main control	3		√	√	62
	MCR	Main control remove	1		√	√	63
	EU	Power flow rising edge detection	2		√	√	60
	ED	Power flow falling edge detection	2		√	√	61
	TON	On-delay timing instruction	5		√	√	65
	TOF	Off-delay timing instruction	5		√	√	66
	TMON	Monostable timing instruction	5		√	√	67
	TONR	On-delay remember timing instruction	5		√	√	66
	CTU	16-bit counter counting up instruction	5		√	√	67
	CTR	16-bit counter loop cycle counting instruction	5		√	√	68
	DCNT	32-bit counting instruction	7		√	√	69
Program control instruction	LBL	Jump label definition	3		√	√	76
	CJ	Conditional jump	3		√	√	77
	CALL	Calling a subprogram	Dependent on the program		√	√	79
	CSRET	Conditional return from user subprogram	1		√	√	79
	CFEND	Conditional end from user main program	1		√	√	77
	CIRET	Conditional return from user interrupt subprogram	1		√	√	78
	FOR	Cycle instruction	3		√	√	75
	NEXT	Return from cycle	1		√	√	75
	WDT	User program watchdog reset	1		√	√	78
	STOP	User program stop	1		√	√	78
	EI	Enable interrupt instruction	1		√	√	78
	DI	Disable interrupt instruction	1		√	√	78
SFC instruction	STL	SFC state load instruction	3		√	√	64
	SET Sxx	SFC state shift	3		√	√	64
	OUT Sxx	SFC state jump	3		√	√	64
	RST Sxx	SFC state reset	3		√	√	65
	RET	SFC program end	1		√	√	65

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Data transmission instruction	MOV	Move word data transmission instruction	5		√	√	80
	DMOV	Move double word data transmission instruction	7		√	√	80
	RMOV	Move floating point number data transmission instruction	7		√	√	81
	BMOV	Move data block transmission instruction	7		√	√	81
	SWAP	Swap bytes	3		√	√	83
Data flow instruction	XCH	Exchange word instruction	5		√	√	83
	DXCH	Exchange double word instruction	7		√	√	84
	FMOV	Fill data block instruction	7		√	√	82
	DFMOV	Fill data block double word instruction	9		√	√	82
	WSFR	Shift right word instruction	9		√	√	87
	WSFL	Shift left word instruction	9		√	√	88
	PUSH	Push instruction	7	Carry	√	√	84
	FIFO	First-in-first-out instruction	7	Zero	√	√	86
	LIFO	Last-in-first-output instruction	7	Zero	√	√	86
Integer / double integer math instruction	ADD	Add integer instructions	7	Zero, Carry, Borrow	√	√	89
	DADD	Add double integer instruction	10	Zero, Carry, Borrow	√	√	93
	SUB	Subtract integer instruction	7	Zero, Carry, Borrow	√	√	89
	DSUB	Subtract double integer instruction	10	Zero, Carry, Borrow	√	√	94
	INC	Increment integer instruction	3		√	√	91
	DINC	Increment double integer instruction	4		√	√	96
	DEC	Decrement integer instruction	3		√	√	92
	DDEC	Decrement double integer instruction	4		√	√	96
	MUL	Multiply integer instruction	8		√	√	90
	DMUL	Multiply double integer instruction	10		√	√	94
	DIV	Divide integer instruction	7		√	√	90
	DDIV	Divide double integer instruction	10		√	√	95
	VABS	Integer absolute value instruction	5		√	√	92
	DVABS	Double integer absolute value instruction	7		√	√	97
	NEG	Negative integer instruction	5		√	√	93
	DNEG	Negative double integer instruction	7		√	√	97
	SQT	Square root integer instructions	5		√	√	91
	DSQT	Square root double integer instruction	7		√	√	95
	SUM	Sum integer instruction	8	Zero	√	√	98
	DSUM	Sum double integer instruction	9	Zero	√	√	99
Floating point number math instruction	RADD	Add floating point number instruction	10	Zero, Carry	√	√	99
	RSUB	Subtract floating point number instruction	10	Zero, Carry	√	√	100
	RMUL	Multiply floating point number instruction	10	Zero, Carry	√	√	100
	RDIV	Divide floating point number instruction	10	Zero, Carry	√	√	101
	RVABS	Floating point number absolute value instruction	7		√	√	102
	RNEG	Floating point number absolute value instruction	7		√	√	102
	RSQT	Square root floating point number instruction	7	Zero	√	√	101
	SIN	Floating point number SIN instruction	7	Zero	√	√	103
	COS	Floating point number COS instruction	7	Zero	√	√	103
	TAN	Floating point number TAN instruction	7	Zero, Carry	√	√	104
	LN	Floating point number LN instruction	7	Zero, Carry	√	√	105
	EXP	Floating point number EXP instruction	7	Zero, Carry	√	√	105
	POWER	Floating point number exponentiation instruction	10	Zero, Carry	√	√	104
	RSUM	Sum floating point number instruction	9		√	√	106

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Word/double word logic instruction	WAND	AND word instruction	7		√	√	115
	DWAND	AND double word instruction	10		√	√	117
	WOR	OR word instruction	7		√	√	116
	DWOR	OR double word instruction	10		√	√	118
	WXOR	Exclusive-OR word instruction	7		√	√	116
	DWXOR	Exclusive-OR double word instruction	10		√	√	118
	WINV	NOT word instruction	5		√	√	117
	DWINV	NOT double word Instruction	7		√	√	119
Shift / rotate instruction	ROR	16-bit circular shift right instruction	7	Carry	√	√	119
	DROR	32-bit circular shift right instruction	9	Carry	√	√	122
	ROL	16-bit circular shift left instruction	7	Carry	√	√	120
	DROL	32-bit circular shift left instruction	9	Carry	√	√	123
	RCR	16-bit carry circular shift right instruction	7	Carry	√	√	121
	DRCR	32-bit carry circular shift right instruction	9	Carry	√	√	123
	RCL	16-bit carry circular shift left instruction	7	Carry	√	√	122
	DRCL	32-bit carry circular shift left instruction	9	Carry	√	√	124
	SHR	16-bit shift right word instruction	7		√	√	124
	DSHR	32-bit shift right instruction	9		√	√	125
	SHL	16-bit shift left instruction	7		√	√	125
	DSHL	32-bit shift left instruction	9		√	√	126
	SFTL	Shift left byte instruction	9		√	√	128
	SFTR	Shift right byte instruction	9		√	√	127
Enhanced bit logic instruction	DECO	Decode instruction	5		√	√	178
	ENCO	Encode instruction	5		√	√	178
	BITS	Counting ON bit in word instruction	5		√	√	179
	DBITS	Counting ON bit in double word instruction	6		√	√	179
	ZRST	Batch bit reset instruction	5		√	√	177
	ZSET	Set batch bit instruction	5		√	√	177
High speed I/O instruction	HCNT	High-speed counter drive instruction	7		√	√	142
	DHSCS	High-speed counting compare set instruction	10		√	√	143
	DHSCR	High-speed counting compare reset instruction	10		√	√	145
	DHSCI	High-speed counting compare interrupt trigger instruction	10		√	√	144
	DHSZ	High-speed counting zone compare instruction	13		√	√	146
	DHST	High-speed counting table compare instruction	10		√	√	147
	DHSP	High-speed counting table compare pulse output instruction	10		√	√	149
	SPD	Pulse detection instruction	7		√	√	151
	PLSY	Count pulse output instruction	9		√	√	152
	PLSR	Count pulse with acceleration/deceleration output instruction	10		√	√	153
	PWM	PWM pulse output instruction	7		√	√	156
	PLS	Pulse Output Instruction of Envelop	7			√	155
Control calculation instruction	PID	PID instruction	9		√	√	157
	RAMP	Ramp wave signal output instruction	12		√	√	160
	TRIANGLE	Triangle wave signal output instruction	12		√	√	162
	HACKLE	Hackle wave signal output instruction	12		√	√	161

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
External equipment instruction	FROM	Read word from special module buffer register instruction	9		√	√	129
	DFROM	Read double word from special module buffer register instruction	10		√	√	130
	TO	Write word to special module buffer register instruction	9		√	√	131
	DTO	Write double word to special module buffer register instruction	10		√	√	132
	VRRD	Read analog potentiometer value instruction	5		√	√	132
	REFF	Set input filtering constant instruction	3		√	√	133
	REF	Instant refresh I/O instruction	5		√	√	133
	EROMWR	Write EEPROM instruction	7			√	134
Locating instruction	ABS	Read current value instruction	8			√	199
	ZRN	Regress to origin instruction	11			√	196
	PLSV	Variable speed pulse output instruction	8			√	197
	DRVI	Control relative position instruction	11			√	198
	DRVA	Control absolute position instruction	11			√	199
Real-time clock instruction	TRD	Read real-time clock instruction	3		√	√	135
	TWR	Write real-time clock instruction	3		√	√	136
	TADD	Add clock instruction	7	Zero, Carry	√	√	137
	TSUB	Subtract clock instruction	7	Zero, Borrow	√	√	138
	HOUR	Timing list instruction	8		√	√	139
Compare contactor instruction	LD=	Compare integer LD= instruction	5		√	√	184
	LDD=	Compare double integer LDD= instruction	7		√	√	187
	LDR=	Compare floating point number LDR= instruction	7		√	√	190
	LD>	Compare interger LD> instruction	5		√	√	184
	LDD>	Compare double integer LDD> instruction	7		√	√	187
	LDR>	Compare floating point number LDR> instruction	7		√	√	190
	LD>=	Compare integer LD>= instruction	5		√	√	184
	LDD>=	Compare double integer LDD>= instruction	7		√	√	187
	LDR>=	Compare floating point number LDR>= instruction	7		√	√	190
	LD<	Compare integer LD< instruction	5		√	√	184
	LDD<	Compare double integer LDD< instruction	7		√	√	187
	LDR<	Compare floating point number LDR< instruction	7		√	√	190
	LD<=	Compare integer LD<= instruction	5		√	√	184
	LDD<=	Compare double integer LDD<= instruction	7		√	√	187
	LDR<=	Compare floating point number LDR<= instruction	7		√	√	190
	LD<>	Compare integer LD<> instruction	5		√	√	184
	LDD<>	Compare double integer LDD<> instruction	7		√	√	187
	LDR<>	Compare floating point number LDR<> instruction	7		√	√	190
	AND=	Compare integer AND= instruction	5		√	√	185
	ANDD=	Compare double integer ANDD= instruction	7		√	√	188
	ANDR=	Compare floating point number ANDR= instruction	7		√	√	191
	AND>	Compare integer AND> instruction	5		√	√	185

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Compare contactor instruction	ANDD>	Compare double integer ANDD> instruction	7		√	√	188
	ANDR>	Compare floating point number ANDR> instruction	7		√	√	191
	AND>=	Compare integer AND>= instruction	5		√	√	185
	ANDD>=	Compare double integer ANDD>= instruction	7		√	√	188
	ANDR>=	Compare floating point number ANDR>= instruction	7		√	√	191
	AND<	Compare integer AND< instruction	5		√	√	185
	ANDD<	Compare double integer ANDD< instruction	7		√	√	188
	ANDR<	Compare floating point number ANDR< instruction	7		√	√	191
	AND<=	Compare integer AND<= instruction	5		√	√	185
	ANDD<=	Compare double integer ANDD<= instruction	7		√	√	188
	ANDR<=	Compare floating point number ANDR<= instruction	7		√	√	191
	AND<>	Compare integer AND<> instruction	5		√	√	185
	ANDD<>	Compare double integer ANDD<> instruction	7		√	√	188
	ANDR<>	Compare floating point number ANDR<> instruction	7		√	√	191
	OR=	Compare integer OR= instruction	5		√	√	186
	ORD=	Compare double integer ORD= instruction	7		√	√	189
	ORR=	Compare floating point number ORR= instruction	7		√	√	192
	OR>	Compare integer OR> instruction	5		√	√	186
	ORD>	Compare double integer ORD> instruction	7		√	√	189
	ORR>	Compare floating point number ORR> instruction	7		√	√	192
Compare contactor instuction	OR>=	Compare integer OR>= instruction	5		√	√	186
	ORD>=	Compare double integer ORD>= instruction	7		√	√	189
	ORR>=	Compare floating point number ORR>= instruction	7		√	√	192
	OR<	Compare integer OR< instruction	5		√	√	186
	ORD<	Compare double integer ORD< instruction	7		√	√	189
	ORR<	Compare floating point number ORR< instruction	7		√	√	192
	OR<=	Compare integer OR<= instruction	5		√	√	186
	ORD<=	Compare double integer ORD<= instruction	7		√	√	189
	ORR<=	Compare floating point number ORR<= instruction	7		√	√	192
	OR<>	Compare integer OR<> instruction	5		√	√	186
	ORD<>	Compare double integer ORD<> instruction	7		√	√	189
	ORR<>	Compare floating point number ORR<> instruction	7		√	√	192

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Data converting instruction	ITD	Integer to double integer instruction	6		√	√	107
	DTI	Double integer to integer instruction	6		√	√	106
	FLT	Integer to floating point number instruction	6		√	√	107
	DFLT	Double integer to floating point number instruction	7		√	√	107
	INT	Floating point number to integer instruction	6	Zero, Carry, Borrow	√	√	108
	DINT	Floating point number to double integer instruction	7	Zero, Carry, Borrow	√	√	108
	BCD	Word to 16-bit BCD instruction	5		√	√	109
	DBCD	Double word to 32-bit BCD instruction	7		√	√	109
	BIN	16-bit BCD to word instruction	5		√	√	110
	DBIN	32-bit BCD to double word instruction	7		√	√	110
	GRY	Word to 16-bit gray code instruction	5		√	√	111
	DGRY	Double word to 32-bit gray code instruction	7		√	√	111
	GBIN	16-bit gray code to word instruction	5		√	√	112
	DGBIN	32-bit gray code to double word instruction	7		√	√	112
	SEGI	Word to 7-segment encode	5		√	√	113
	ASC	ASCII Code conversion instruction	19			√	113
	ITA	hexadecimal integer-ASCII conversion instruction	7			√	114
	ATI	ASCII-hexadecimal integer conversion instruction	7			√	115
Word contactor instruction	BLD	Word bit contactor LD instruction	5		√	√	180
	BLDI	Word bit contactor LDI instruction	5		√	√	180
	BAND	Word bit contactor AND instruction	5		√	√	181
	BANI	Word bit contactor ANI instruction	5		√	√	181
	BOR	Word bit contactor OR instruction	5		√	√	182
	BORI	Word bit contactor ORI instruction	5		√	√	182
	BSET	Word bit coil set instruction	5		√	√	183
	BRST	Word bit coil reset instruction	5		√	√	183
	BOUT	Word bit coil output instruction	5		√	√	183
Communication instruction	Modbus	Modbus master station communication instruction	8		√	√	164
	XMT	Free-port sending (XMT) instruction	7		√	√	172
	RCV	Free-port receiving (RCV) instruction	7		√	√	173
	IVFWD	FREQUENCY CONVERTER forward rotation instruction	6			√	165
	IVREV	FREQUENCY CONVERTER reverse rotation instruction	6			√	166
	IVDFWD	FREQUENCY CONVERTER touch forward rotation instruction	6			√	166
	IVDREV	FREQUENCY CONVERTER touch reverse rotation instruction	6			√	167
	IVSTOP	FREQUENCY CONVERTER stop instruction	8			√	167
	IVFRQ	FREQUENCY CONVERTER set frequency instruction	8			√	168
	IVWRT	FREQUENCY CONVERTER write single register value instruction	10			√	169
	IVRDST	FREQUENCY CONVERTER read status instruction	10			√	170
	IVRD	FREQUENCY CONVERTER read single register value instruction	10			√	171

	Instruction	Instruction function	Program steps	Influenced flag bit	IVC2	IVC1	Page
Data check instruction	CCITT	CCITT check instruction	7		√	√	174
	CRC16	CRC16 check instruction	7		√	√	175
	LRC	LRC check instruction	7		√	√	176
Compare date instruction	DCMP=	Compare date= instruction	7		√	√	140
	DCMP>	Compare date> instruction	7		√	√	140
	DCMP<	Compare date< instruction	7		√	√	140
	DCMP>=	Compare date>= instruction	7		√	√	140
	DCMP<=	Compare date<= instruction	7		√	√	140
	DCMP<>	Compare date<> instruction	7		√	√	140
Compare time instruction	TCMP=	Compare time= instruction	7		√	√	141
	TCMP>	Compare time> instruction	7		√	√	141
	TCMP<	Compare time< instruction	7		√	√	141
	TCMP>=	Compare time>= instruction	7		√	√	141
	TCMP<=	Compare time<= instruction	7		√	√	141
	TCMP<>	Compare time<> instruction	7		√	√	141